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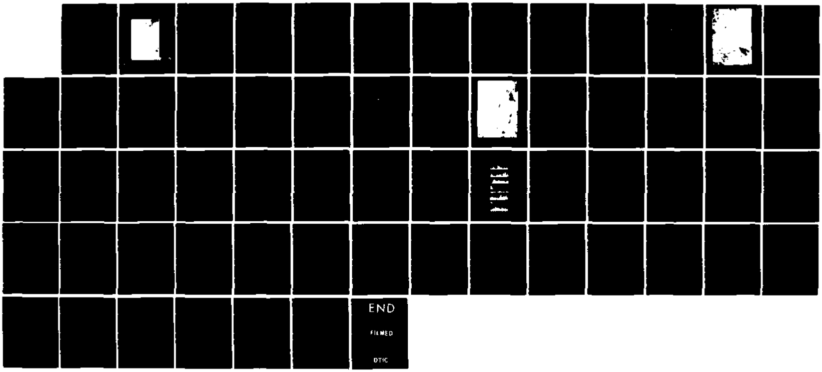

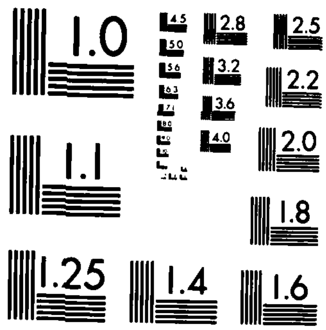

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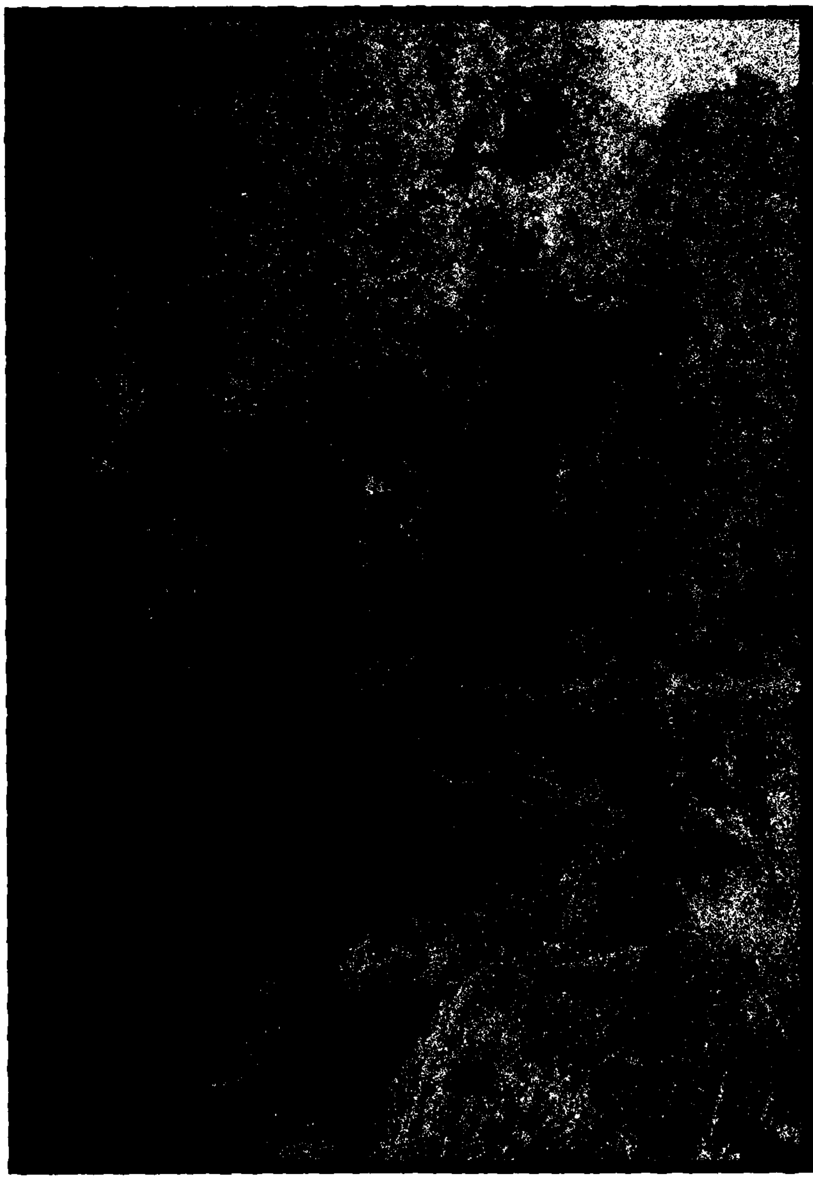
PALEOENVIRONMENTAL INVESTIGATIONS AT SEED CAVE (WINDUST CAVE H-45FR46), FRANKLIN COUNTY, WASHINGTON

By

Robert S. Thompson



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Archaeological and Historical Services
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Investigations were conducted at Seed Cave to recover paleoenvironmental data being destroyed by relic collectors. Excavations exposed a profile over 5.5m in depth. Radiocarbon and stratigraphic evidence, combined with floral and faunal remains, indicates changes in the local environment during the last 9000 years: 9000-6400 B.P. relatively cooler and moister; 6400-4100 B.P. considerably drier; 4100-3500 B.P. relatively moister conditions based on faunal and sediment data while the pollen spectra indicates conditions more arid than

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) at present. Data for the last 3500 years indicate no substantial environmental changes around Seed Cave.

PALEOENVIRONMENTAL INVESTIGATIONS AT SEED CAVE (WINDUST CAVE H-45FR46), FRANKLIN COUNTY, WASHINGTON

By
Robert S. Thompson

With contributions by
Glenn D. Hartmann
Jim I. Mead
Emilee Mead
and
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ABSTRACT

Investigations were conducted at Seed Cave (Windust Cave H, 45FR46) in the summer of 1983 to recover paleoenvironmental data being destroyed by relic collectors. Excavations exposed a profile over 5.5 m in depth. Paleoenvironmental analysis included stratigraphic, pollen, plant macrofossil, and floral analyses and radiocarbon dating. The paucity of prehistoric cultural materials effectively precluded any archaeological analysis. Radiocarbon and stratigraphic evidence, combined with floral and faunal remains, indicates changes in the local environment during the last 9000 years. There is some suggestion that conditions were relatively cooler and moister ca. 9000 to 6400 years ago. The period between 6400 and 4100 B.P. is interpreted to be considerably drier based on stratigraphic analysis. Faunal and pollen data are lacking in the cave sediments for this period. From 4100 to ca. 3500 years ago, faunal and sediments data indicate relatively moister conditions, while the pollen spectra indicate conditions more arid than at present. Data for the last 3500 years indicate no substantial environmental changes around Seed Cave; however, there are clear indications of the effects of historic activities and the introduction of exotic floral species.

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1. INTRODUCTION

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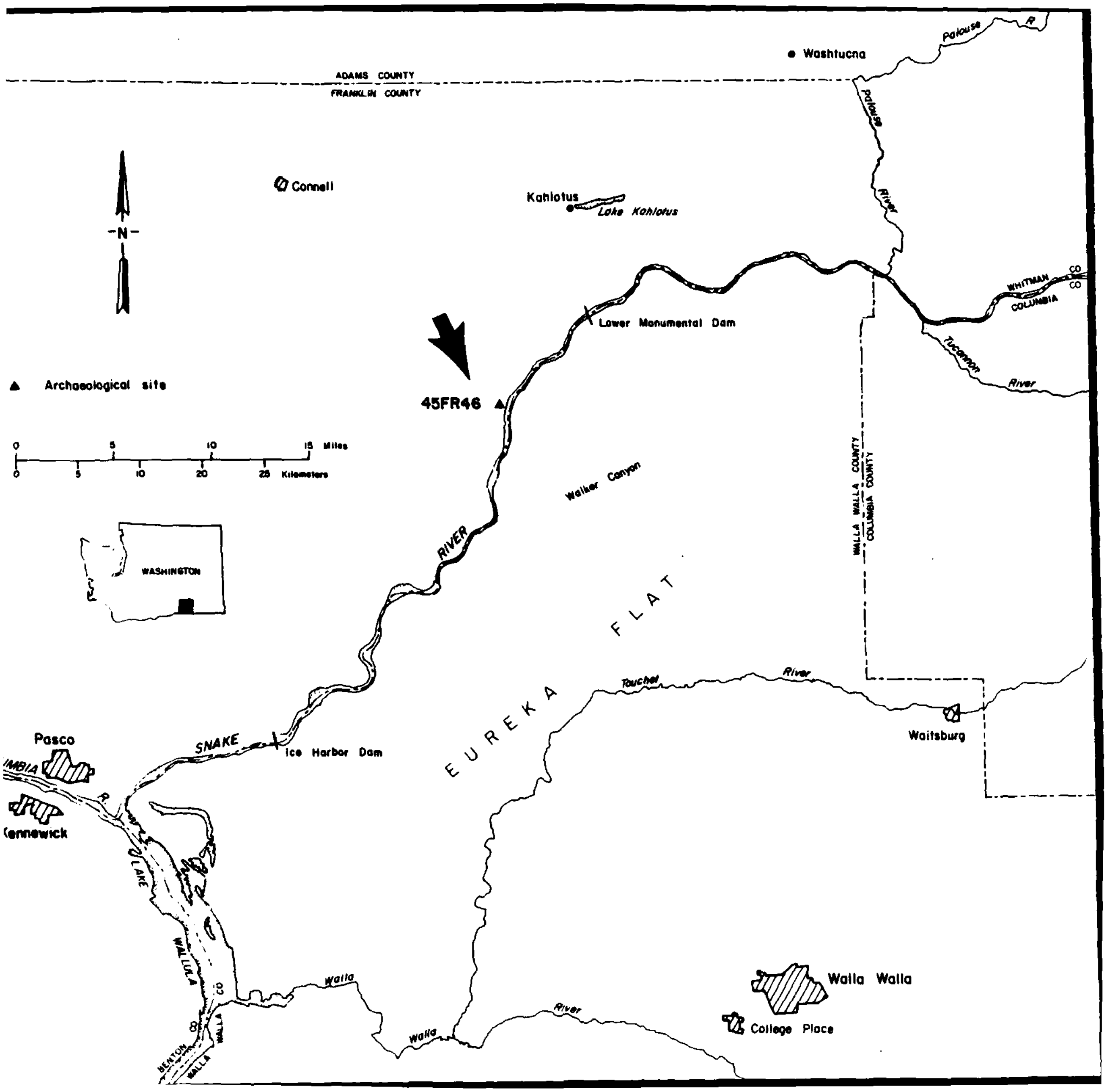
Seed Cave, also known as Windust Cave H (Rice 1965), is a narrow fissure cave in a basalt cliff overlooking the Ice Harbor Reservoir (the pool in the Snake River impounded behind Ice Harbor Dam) in Franklin County, Washington (Figures 1 and 2). This cave is one of nine fissures in a row along this cliff face, and these are known collectively as the Windust Caves (Rice 1965). While Seed Cave was originally more than 15 m (50 ft) above the Snake River, the top of the sediments in the cave is now only 5.5 m (18 ft) above the reservoir level. Seed Cave is located in the southeast corner of Section 24, T12N, R33E, and is approximately 290 m (950 ft) downstream from Windust Cave C, the main archaeological site. The elevation of Seed Cave is about 137 m (450 ft) above sea level.

Natural Environment

The Windust Caves lie within the *Agropyron*-*Poa* natural vegetation zone (Daubenmire 1970) that lined the Snake River in southeastern Washington before the disturbances of the last century. Prior to the damming of the river, riparian trees, including *Populus* and *Salix*, grew along its banks (Asherin and Claar 1976). The Douglas hackberry (*Celtis douglasii*) is common along cliff bases in the region and grows at the entrance to Windust Cave C today. It also has grown at the entrance to Seed Cave through most of the Holocene, and the abundance of the calcareous endocarps of this plant in the cave sediments was the source of the appellation "Seed Cave" (Gross 1979).

The upland natural vegetation near Seed Cave falls into the *Agropyron*-*Festuca* vegetation zone (Daubenmire 1970) and more xeric *Artemisia*-dominated communities occur approximately 15 to 25 km (10 to 15 mi) to the north and west of Seed Cave. The nearest forest vegetation lies about 50 km (30 mi) to the southeast in the Blue Mountains. The mean annual precipitation in the Windust Cave region is in the range of 250-300 mm (10-12 in) and falls primarily in the cooler months. Mean January minima are around -6° C (21° F), and July mean maxima are approximately 32° C (90° F). These figures are for the upland area, and temperatures are generally warmer and precipitation is less at the low elevations near the Snake River.



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45FR46
0 5 10 15 Miles
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Walker Canyon
WALLA WALLA COUNTY
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WASHINGTON
RIVER
EUREKA FLAT
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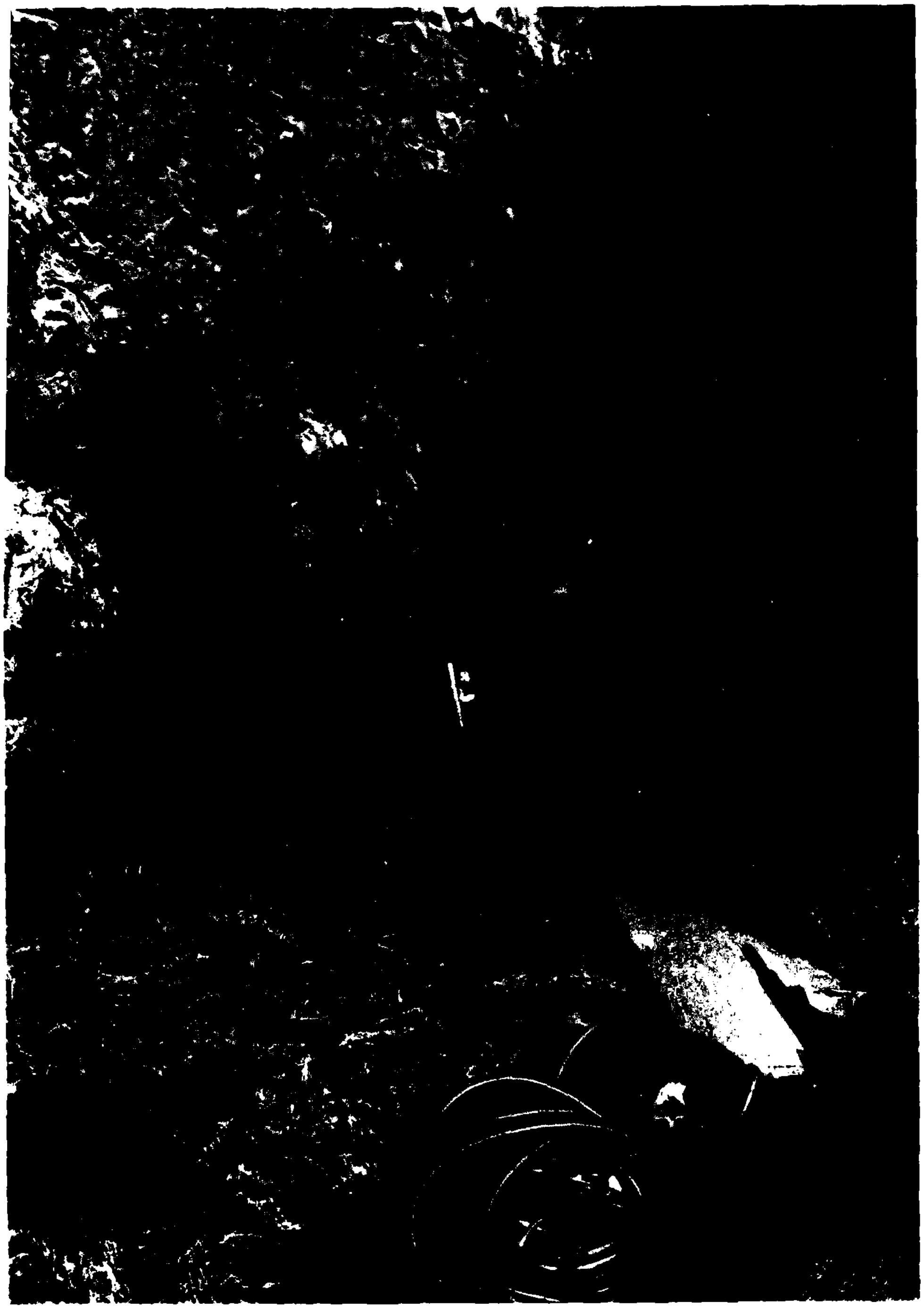


Figure 2. Photograph showing entrance to Seed Cave (Cave H). Cave I is to the left of people in center. View to the north.

Past Environmental Changes in Southeastern Washington

The region surrounding Seed Cave has been greatly affected by late Pleistocene and Holocene environmental changes and catastrophic events. During the Late Wisconsinan, the surficial deposits of the area were stripped to bedrock by recurrent, massive floods resulting from the sudden release of water from Lake Bonneville (Malde 1968; Hammatt 1977) and Lake Missoula (Bretz 1969; Baker 1971, 1981; Mullineaux et al. 1978; Bunker 1982; Clark et al. 1984). Clouds of volcanic ash have wafted across eastern Washington on several occasions, and widespread tephra layers were deposited from eruptions of Glacier Peak, Mount St. Helens, and Mount Mazama (Fryxell 1965, 1972; Kittleman 1973, 1979; Mack et al. 1979; Mehringer el al. 1977; Mullineaux et al. 1972, 1975; Porter 1978; Powers and Wilcox 1964; Smith et al. 1977; Wilcox 1965).

In addition to the catastrophic events mentioned above, long term environmental fluctuations are also recorded in the geologic record. Variations in climatic conditions over the last 13,000 years are seen in changes in alluvial and aeolian records (Hammatt 1977; Marshall 1971) and perhaps in changes in rock spall activity (Fryxell et al. 1965).

The vegetation of the region has also undergone climatically induced changes. The modern distributions of several xerophytic plant species suggest that they migrated into what are now more mesic regions during a period of middle Holocene aridity (Daubenmire 1975). Regional pollen records (Hansen 1947; Mack et al. 1976; Nickman 1979) also seem to indicate that eastern Washington experienced a period of warmer- and drier-than-modern conditions in the early to middle Holocene. Interestingly, the timing of this period may not correspond with the period of maximum warmth on the western side of the Cascades (Barnosky 1983). In addition to changes in response to climatic fluctuations, the vegetation of southeastern Washington has undergone major changes in response to the historic introduction of grazing animals and Eurasian steppe plants (Davis et al. 1977).

The fauna of eastern Washington have also changed through time. Pleistocene large mammals that once roamed the region (Martin et al. 1983; Newcomb and Repenning 1970; Scott 1967) apparently disappeared by the beginning of the Holocene. Other smaller and still extant boreal mammals, such as the pine marten and arctic fox, lived in eastern Washington at the end of the Pleistocene (Lyman and Livingston 1983). These latter animals were recovered from sediments at Marmes Shelter (Gustafson 1972), and demonstrate that cooler and perhaps forested conditions once prevailed there. The modern distribution of the pygmy rabbit (Sylvilagus idahoensis) in the interior Northwest may provide evidence of mammal migrations in response to warmer materials are present throughout. This "hole" may be the same one that shows up in Rice's (1965) profile from Seed Cave.

11	432-452 cm bd.	Angular roof spall fragments in a fine micaceous sand matrix. Mica chips as large as 1.5 mm are present. Color of matrix is 10YR 4/4 (dry). Celtis seeds are very abundant and small bones are common. An apparent compression crack, filled with sand, is continuous through the northern part of this stratum with a crack through Stratum 9. Upper boundary of Stratum 11 is distinct and slopes sharply upward toward the north wall. Lower boundary is very distinct and has a much more gentle slope. On the southern side, this stratum is truncated by Stratum 10.
12	452-454 cm bd.	This is a lens of fine micaceous sand (10YR 4/3, dry) with small inclusions of volcanic ash. This stratum is continuous with the large apparent compression crack through Strata 9 and 11 and may simply be an extension of this crack. Stratum 12 has very distinct boundaries.
13	454-482 cm bd.	Roof spall fragments in a matrix of fine micaceous sand. Color of matrix is 10YR 4/6 (dry). Celtis seeds and small bones are very abundant. This stratum is very similar to Stratum 11 and may be a continuation of it, since the two are separated only by what may be a compression crack (Stratum 12). The only observed differences between Strata 11 and 13 are slight variations in color and a higher frequency of large (greater than 5 cm) roof spall fragments in the lower stratum. Two rounded river cobbles (5 to 10 cm in diameter) were found in Stratum 13.
14	482-484 cm bd.	This is a thin (2 to 3 cm) undulating lens of fine micaceous sand. Color of this sediment is 10YR 4/4 (dry).
15	484-486 cm bd.	This stratum is a thin layer of Celtis seeds and small bones in a fine micaceous sand matrix. This layer follows the same undulating path across the profile that the overlying stratum does. Matrix color is 10YR 3/6 (dry).
16	486-490 cm bd.	This is a thin undulating bed of fine micaceous sand (10YR 5/4, dry). Clasts of volcanic ash are present and organic remains are rare.
17	490-506 cm bd.	Angular roof spall in a fine micaceous sand/silt matrix. The color of the matrix is 10YR 4/5 (dry). Celtis seeds and small bones are present, and the upper and lower boundaries of the stratum are distinct. Unit slopes up abruptly toward the north wall.
18	504-513 cm bd.	Micaceous fine sand and silt with abundant organic remains. Celtis seed fragments are very abundant, as are small bones. By this depth, the bones are stained a reddish hue. Matrix color is 10YR 4/4. The upper and lower stratum boundaries are distinct, and the stratum slopes up sharply toward the north wall of the excavation unit, as in Stratum 17. Some pieces of the matrix from Stratum 18 held together as if they had formed one horizontal surface, and these pieces seem to have high clay content.

		and 5c are somewhat larger than in 5a (up to 15 cm vs. less than 3 cm). Depth of 5b along the centerline of the profile is 195 to 305 cm bd. 5b underlies 5a in the southern two-thirds of the profile and a wedge of 5b separates 5a from 5c. 5c is very similar to 5a except for small differences in color (the matrix color of 5c is 10YR 3/4 (dry), and the previously mentioned differences in maximum spall size. 5c extends in depth from 164 to 330 cm bd along the north wall, and along the centerline it goes from 305 to 336 cm bd (here it underlies 5b). A large krotovina occurs in 5c at 290 cm bd (diameter of this feature = 15 cm). A small (3 to 4 cm in thickness) burned horizon occurs near 320 cm bd.
6	336-340 cm bd.	Very fine micaceous sand, with some silt and clay present. Organic materials (<u>Celtis</u> seeds, small bones) and small (less than 2 mm) rock fragments are present in small numbers. Matrix color is 10YR 5/3 (dry). This stratum has distinct upper and lower boundaries and slopes upward toward the north wall of the excavation unit.
7	340-343 cm bd.	Silt (10YR 7/2, dry) that is very rich in volcanic ash. A few very small (less than 2 mm) rock fragments are present. This stratum is approximately 3 to 4 cm thick across the profile and has the same sloping trajectory as Stratum 6. The upper and lower boundaries of Stratum 7 are abrupt.
8	343-378 cm bd.	Angular roof spall (up to 15 cm in maximum diameter) in a fine micaceous sand/silt matrix. Some clay is present. Color of matrix is 10YR 5/3 (dry). Upper and lower boundaries are distinct and this stratum has more-or-less the same slope across the profile that the two strata above it have. <u>Celtis</u> seeds and small bones are present. Some small amounts of volcanic ash may be included in this sediment.
9[2]	378-432 cm bd.	Silt, very rich in volcanic ash. A few fragments of small roof spall are present in this matrix. Little organic material is present. Upper and lower boundaries are abrupt; lower boundary angles sharply and is much higher along the north wall of the excavation unit (ca. 390 cm bd) than in the center of the profile. Matrix color is 10YR 7/3 (dry). Lower portion of this stratum contains a number of apparent compression cracks that have become filled with very fine micaceous sand (10YR 4/3, dry). Below 400 cm bd, Stratum 9 is truncated in the southern half of the profile by an apparent pot hunter's disturbance (Stratum 10). The volcanic ash in Stratum 9 contains many tubular shards like those usually found in the tephra from Mount Mazama. This depositional unit pinches out toward the front of the shelter and was apparently absent from the sediments in Windust Cave C (Rice 1965). Curved lines of reddish stains (iron compounds?) were observed throughout Stratum 9.
10	400-456 cm bd.	Mixed sediments, including charcoal, volcanic ash-rich silt, and organic materials. At 400 cm bd, this stratum extends 65 cm out from the south wall of the excavation unit (Unit B). Below this level, the lower boundary follows a curved path and terminates at 456 cm bd at the intersection of the southern and western walls. This deposit is evidently the result of a pot-hunter's disturbance, since historic

Table 1. The Stratigraphy of Seed Cave (Windust Cave H).

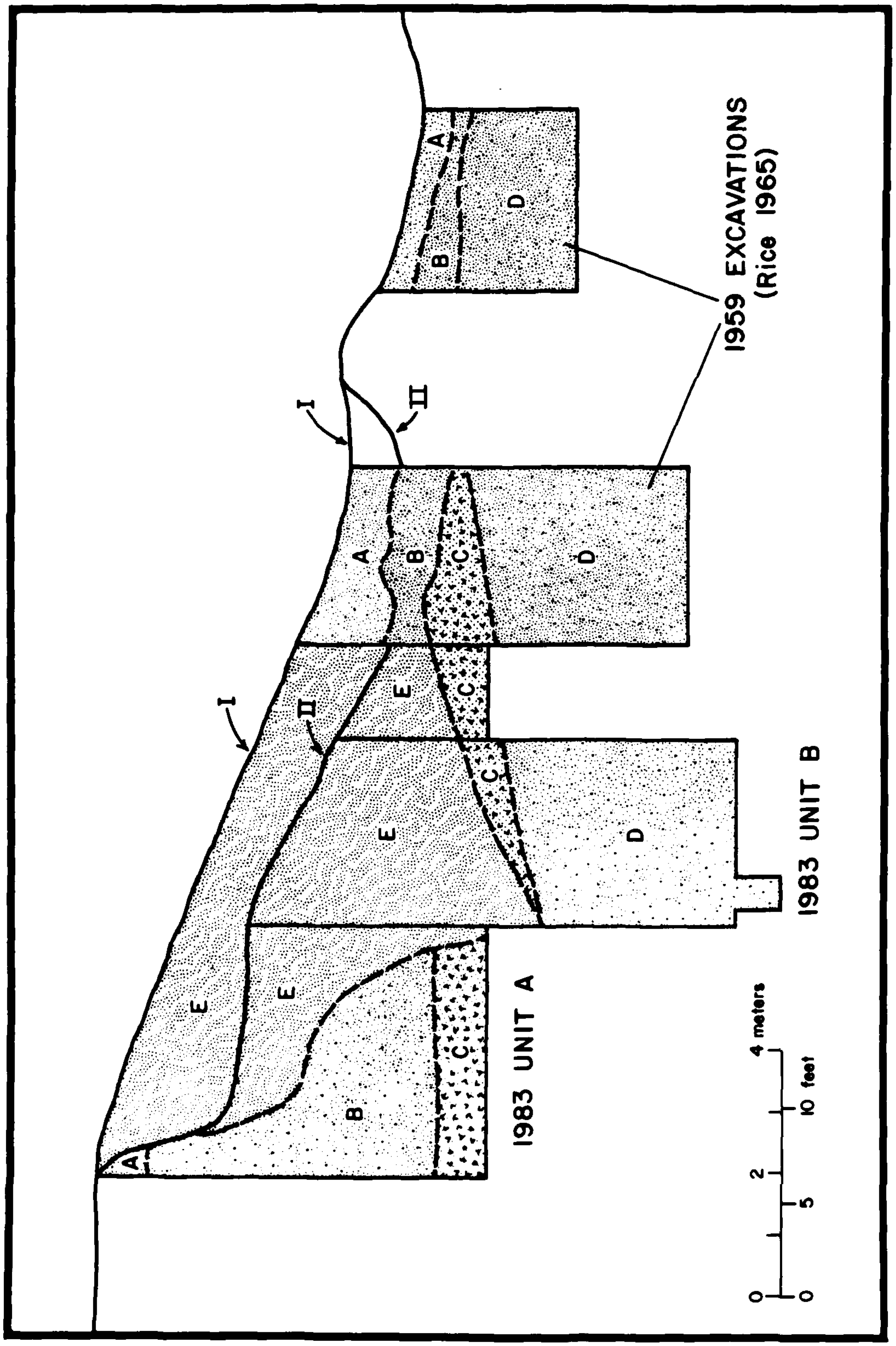
Stratum	Depth	Description
1	80-112 cm bd.	Angular roof spall in a fine micaceous sand/silt matrix. Largest rocks are ca. 15 cm in maximum diameter. Matrix color is 10YR 4/4 (dry). Unit contains many Celtis leaves, seeds, and stems, as well as other organic materials. Rope, newspaper, cloth, and other historic artifacts are common throughout this stratum. The newspaper bears a 1914 date. Lower boundary is abrupt.
2	112-134 cm bd.	This depositional unit is divided into two parts. Stratum 2a is composed of angular roof spall in a fine micaceous sand/silt matrix. Largest rocks are around 15 cm in maximum diameter. Matrix color is 10YR 4/3 (dry). Unit contains many Celtis macrofossils, other plant remains, and prodigious numbers of fecal pellets from small mammals. Stratum 2a covers the northern two-thirds of the profile of this level, as well as a small pocket in the upper part of this depth range near the southern wall of the excavation unit. Stratum 2b resembles 2a except that the sediments of 2b apparently burned in place following deposition. Matrix color in Stratum 2b is 10YR 2/1 (dry).
3	134-174 cm bd.	This stratum is also subdivided into two parts. Stratum 3a is composed of angular small roof spall fragments in a fine micaceous sand/silt matrix. Organic remains are less abundant than in the overlying strata and the sediments are somewhat more compacted. Matrix color is 10YR 5/3 (dry). Upper boundary is distinct, lower boundary (with 3b) is gradational. Stratum 3 is present only in the northern third to half of the profile. Stratum 4 occupies the same depth range in the southern sector. Strata 3 and 4 interdigitate. Stratum 3b is similar in color and composition to 3a, though the roof spall blocks may be somewhat larger in 3b. These subdivisions of Stratum 3 are separated for part of their horizontal extents by a wedge of Stratum 4.
4	134-174 cm bd.	Very fine micaceous sand. Some silt and clay are present in this matrix, as well as mica chips as large as 2 mm in diameter. Fine laminations are present near the base of this stratum. Color of the matrix is 10YR 5/3 (dry). Stratum 4 is thickest at the south end of the profile where it is 45 cm thick. This depositional unit has an abrupt lower boundary. In the profile drawn by Gross (1979), from a section approximately 1.5 to 2 m closer to the cave entrance, this stratum appears as a 100 x 50 cm oval.
5	134-174 cm bd.	This is a large complex stratum that can be subdivided into three parts. Stratum 5a is composed of small (less than 3 cm) angular roof spall fragments in a fine micaceous sand/silt matrix. This portion of Stratum 5 ranges from 174 to 195 cm bd in the center of the profile. The matrix color is 10YR 5/3 (dry). Celtis seeds and other organic remains are abundant. 5b is similar to 5a and 5c except that the sediments of 5b apparently burned in place following deposition. The matrix color of 5b is 10YR 2/1 (dry). The pieces of spall in 5b

4. STRATIGRAPHIC ANALYSIS

Robert S. Thompson

For this aspect of the research, Thomas W. Stafford, Jr., of the Department of Geosciences, University of Arizona, was consulted. As an initial step, field descriptions of the sedimentary units were developed and supplemented with observations made in the laboratory (Table 1). From these observations, photographs, and direct examination of the bulk sediment samples, it was attempted to find the depositional mode of each stratigraphic unit. Unfortunately, this was a "real world" situation and it was usually not possible to find unequivocal modes for most strata. Instead, a series of hypotheses for the sources of these deposits was developed.

As can be seen in Table 1, though some of the characteristics of the strata vary, almost all depositional units have fine micaceous sand/silt matrices. These matrix materials are relatively poorly sorted, and in most strata, all grain sizes from clay to medium sand are present. The possible sources of this matrix sediment include: 1) overbank deposits from floods of the Snake River, 2) sediments derived from the interstitial waters flowing through colluvial deposits, 3) aeolian deposits, and 4) combinations of the above three. Seed Cave was fairly high above the Snake River, and this argues against hypothesis No. 1. Additionally, nearly all strata have this matrix and it is unlikely that floods were that frequent. However, the matrix material may include sediments reworked from late Pleistocene or early Holocene high flood deposits. Hypothesis No. 2 seems more likely, although it is difficult to imagine that colluvial flows could be deposited on the high sediment surfaces in the back of the cave since these deposits are well above the elevation of the cave entrance. However, it is possible that some of this material could flow in through passages in the back of Seed Cave that have not been found. The third hypothesis, aeolian deposition, is not supported by the lack of sorting in the matrix and the inclusion of large chips of mica (up to 2 mm in size). The occurrence of some aeolian activity is attested to by the presence of thick deposits of fine volcanic ash-rich silt (Stratum 9) which apparently is the result of wind transport. It seems most likely that all of these processes have been operating through time (hypothesis No. 4), and that other sources of sediment have also been important. In the uppermost stratigraphic units, small animals have seemingly contributed large amounts of organic materials to the sediments. Additionally, roof spall from the cave walls has added large amounts of material to the cave deposits. The largest blocks of roof spall are in the low-


1959 EXCAVATIONS
(Rice 1965)
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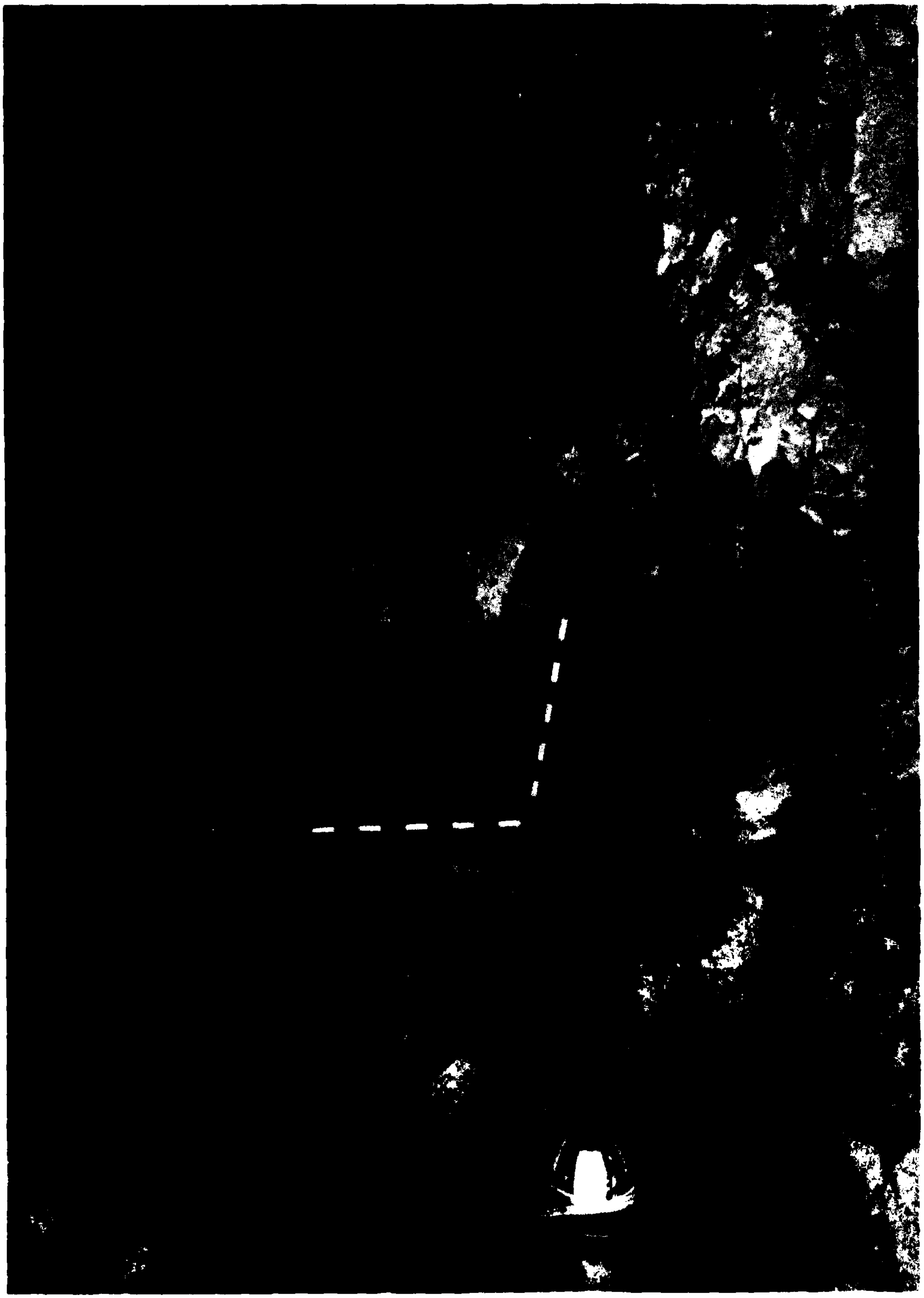

Figure 7. Photograph showing the exposed profile of Unit A. Meter stick rests on middle Holocene ash-rich loess (Stratum 9). Person is standing on the bottom of Unit B.

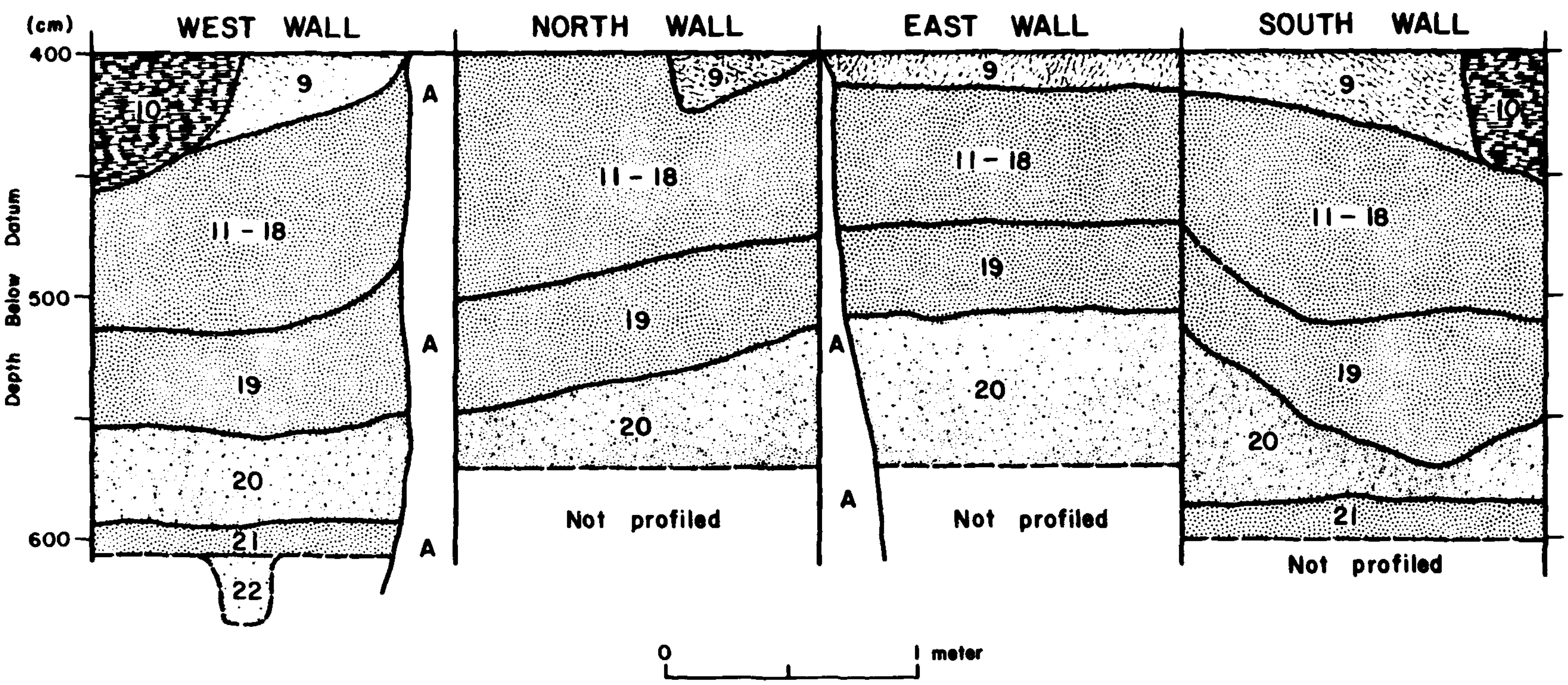

Figure 6. Stratigraphy of Excavation Unit B (200-350 cm east of horizontal datum line). The profile of the far west wall is the source of the stratigraphic descriptions for 400-600 below datum (see Table 1). All stratigraphic designations are listed in Table 1.

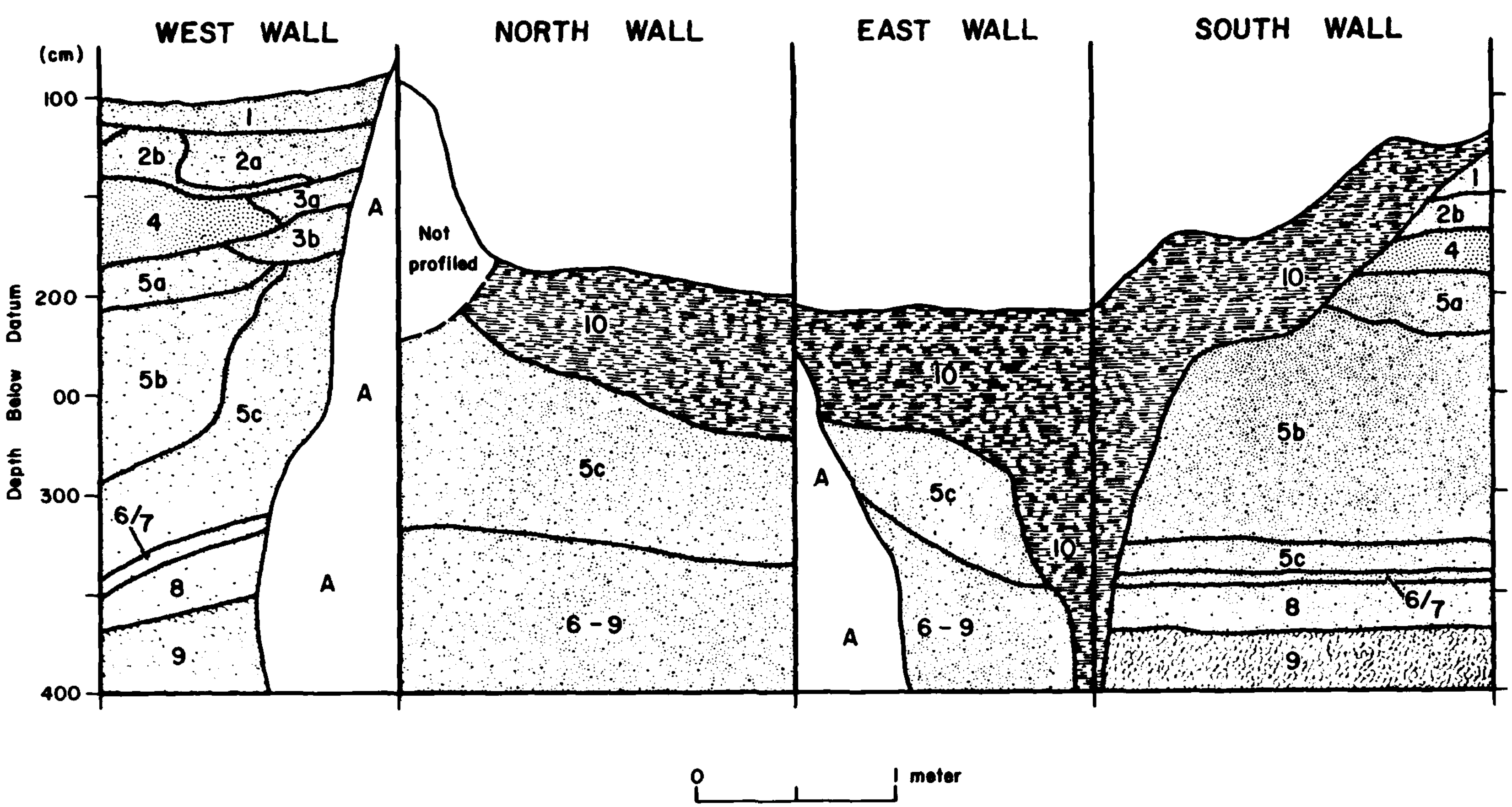

Figure 5. Stratigraphy of 1983 Excavation Unit A (0-200 cm east of horizontal datum line). The profile on the far left (west wall) is the source of the stratigraphic descriptions for 80-400 cm below datum (see Table 1). All stratigraphic designations are listed in Table 1.

3. EXCAVATION PROCEDURES

Robert S. Thompson

During the investigation, two units were excavated: Unit A (0-200 cm east of the horizontal datum line) which was excavated to a depth of 400 cm below an arbitrary vertical datum control line, and Unit B (200-350 cm east) which was excavated to a depth of 630 cm below datum. Together, these adjacent excavation units near the back of the cave provided a 550-cm vertical exposure of the sediments (Figures 5, 6, and 7). As little primary sediment was removed as possible in order to cause the least possible destruction to undisturbed portions of the resource, and much of the sediment removed had been disturbed by historic activities (Figure 8). All primary sediment removed from the cave was wet-screened through 1/4- or 1/8-inch screens.

In the field, the stratigraphic units from the exposed walls were described, the strata measured, and archival photographs taken. Radiocarbon samples, volcanic ash samples, and bulk sediment samples were collected from the freshly exposed walls. Pollen samples were collected from each stratigraphic unit in 10-cm intervals. Modern surface samples from inside and outside of the cave were collected for calibration of the pollen data. Due to the impoundment of the river, it was difficult to find modern analogues for the geologic setting of the cave to aid in the interpretation of the stratigraphic record.

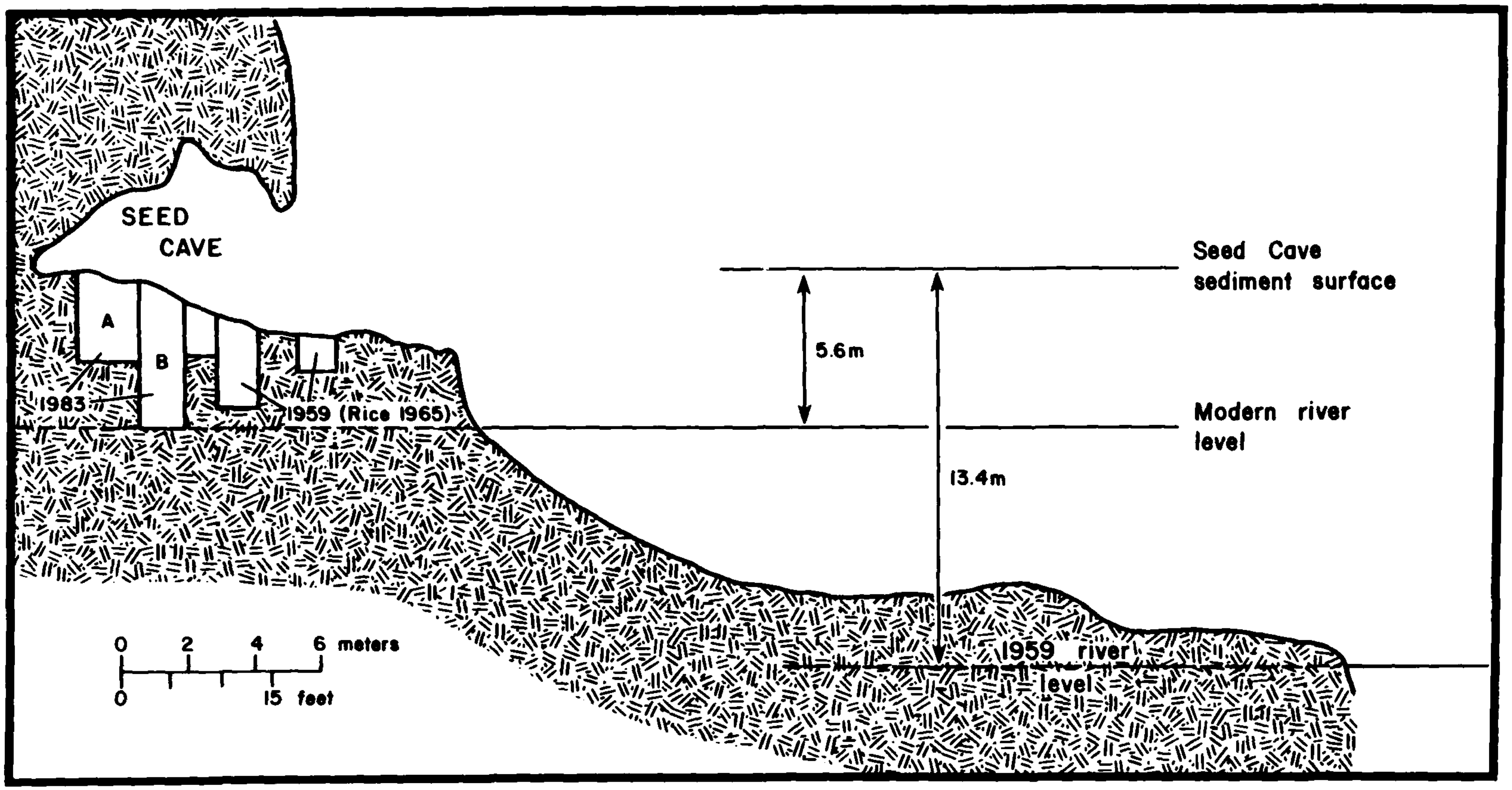

Figure 4. Cross section showing the relative positions of the 1959 and 1983 excavation units and the pre- and post-dam levels of the Snake River. View to the northeast. (Modified from Rice 1965.)

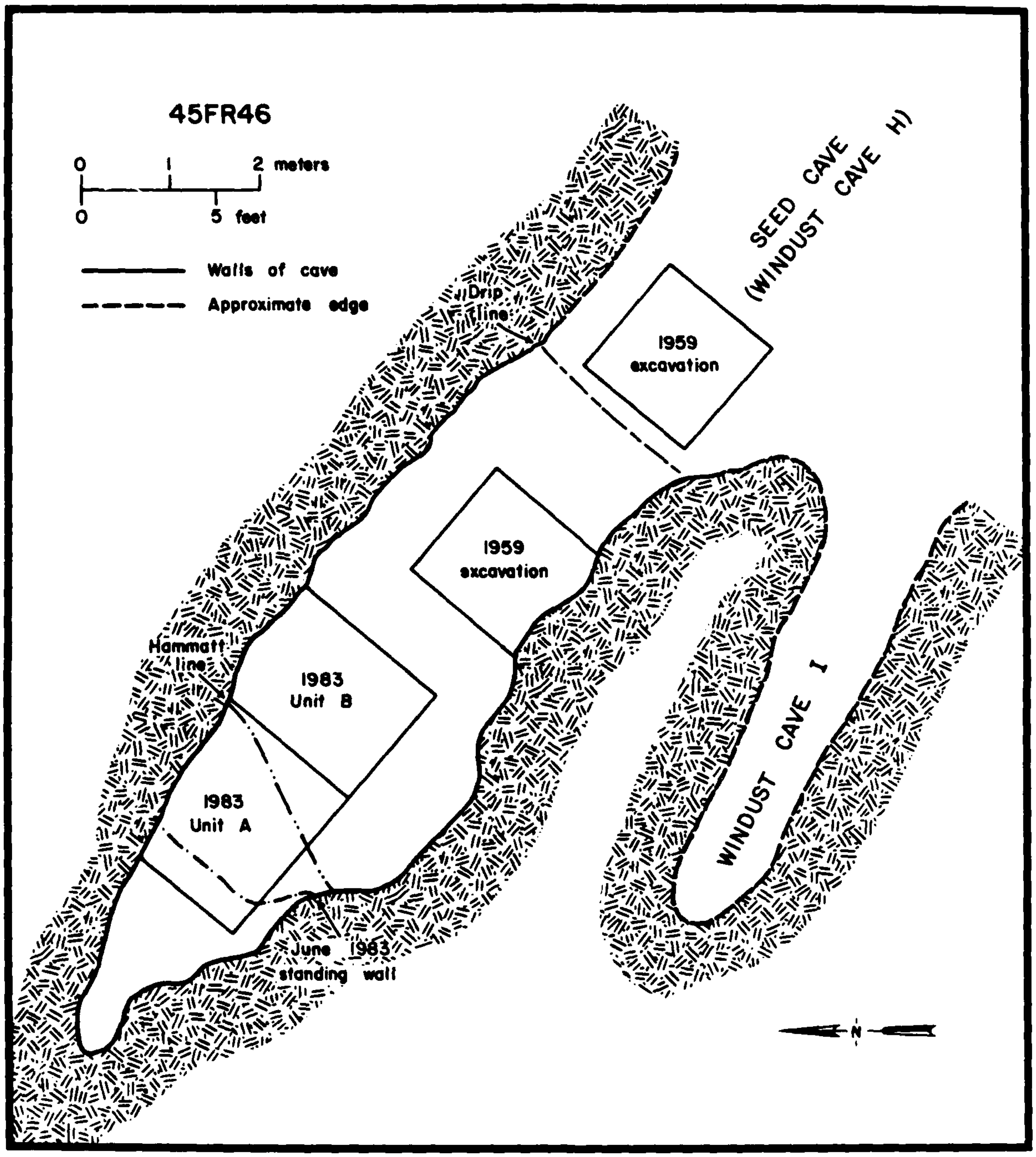

Figure 3. Map of Seed Cave (Cave H) showing positions of 1959 and 1983 excavation units. "Hammatt Line" refers to the position of the standing wall of sediments in the mid-1970s when H.H. Hammatt visited the cave. The solid cave outline represents areas that were mapped during the 1983 excavation; the dotted line represents modifications from Rice (1965).

are undisturbed by past human activities may provide more information than sediments which have the mark of human influence.

The paleoenvironmental investigations involved stratigraphic analysis, radiocarbon dating, and the analysis of fossil pollen, plant macrofossils, and faunal remains. The overall objective of all of these studies was to attempt to provide an integrated chronology of the changing environments and climatic regimes of this portion of southeastern Washington.

2. INVESTIGATIONS AT SEED CAVE

Robert S. Thompson

Previous Investigations

The archaeological potential of Seed Cave was originally explored by Harvey S. Rice in 1959. In that year, Rice excavated two test units near the entrance of Seed Cave (Figures 3 and 4), and began a program of excavation in Windust Cave C that continued for several years (Rice 1965). Seed Cave provided little archaeological information and Rice did no further work at this site. Seed Cave was visited by Hallett Hammatt and others in the mid-1970s as part of a regional archaeological survey, but no further testing was performed (Cleveland et al. 1976). In the late 1970s, Timothy Gross compiled an evaluation of the resource potential of Seed Cave. Gross did not excavate new units, but rather collected samples for laboratory analysis from standing walls of exposed sediment (Gross 1979). At this time, a sketch was drawn of the upper sediments in the cave and these deposits were described. Plant macrofossils (mainly *Celtis* endocarps) and bones were recovered from these exposed sediments. Laboratory analysis of the pollen content of the samples from Seed Cave demonstrated that pollen was present above the thick bed of volcanic ash, but apparently was absent in the underlying sediments.

Current Investigations

Under a contract with the U.S. Army Corps of Engineers, Archaeological and Historical Services (AHS) at Eastern Washington University returned to Seed Cave in the summer of 1983. The field crew, directed by Glenn Hartmann and Robert Thompson, spent 10 days excavating new units near the back of the cave, describing the sediments, and collecting samples for laboratory analysis. Two units were dug and a wall of sediments approximately 5.5 m (18 ft) tall was exposed. The floor of the cave was not uncovered as excavations ceased when the water table was reached. Very few archaeological materials were recovered during the current investigation. The total number of prehistoric artifacts recovered includes a single projectile point, a few flakes, and a few pieces of possibly worked bone. However, the major objective of this study was not to recover artifacts, but rather to provide the paleoenvironmental background for archaeological interpretations. Toward this end, cave sediments that and drier middle Holocene conditions (Grayson 1983:95). Similarly, the past distributions of bison and pronghorn antelope in eastern Washington may be a reflection of a warm and/or dry climate in the middle Holocene (Lyman and Livingston 1983).

19	513-558 cm bd.	Fine micaceous sand with some amounts of silt and clay present. Color is 10YR 4/4 (dry). Relatively few organic remains are present in this unit. The sediments of this stratum are relatively moist in comparison to higher strata. Dark, roughly horizontal stains are present and may reflect the past translocation of minerals (magnesium and/or iron compounds) within or through this stratum. Stratum 19 is relatively massive, though there are some platy structures present. Volcanic ash "balls" are present at approximately 514-520 and 522-527 cm bd. These "balls" are very rounded and are up to 1 cm in diameter. Samples from these clasts were examined at 400X magnification and tubular structures, like those usually found in tephra from Mount Mazama, were not observed. The upper and lower boundaries of this stratum are distinct. Occasional rounded cobbles (less than 10 cm in diameter) were observed in Stratum 19.
20	558-595 cm bd.	Angular roof spall (up to 20 cm in diameter) in a fine micaceous sand/silt matrix. Color is 10YR 3/4 (dry) and matrix includes some clay-sized particles. Mica chips as large as 1 mm in diameter were also observed. Reddish-stained bones are extremely abundant and the faunal analyst (Jim I. Mead) believes that these bones show signs of having been rolled in water transport. These sediments are very moist.
21	595-608 cm bd.	Fine micaceous sand with smaller amounts of silt and clay. Mica chips up to 1 mm in diameter are present. Color of this matrix is 10YR 4/3 (dry). Platy structures and some horizontal bedding are present within this stratum. Organic materials are sparse within this unit. These sediments are very moist and water began to puddle in the bottom of the unit during excavation.
22	608-630+ cm bd.	Angular roof spall in matrix of fine micaceous sand and silt. Upon reaching the water table, excavation was halted at 608 cm bd. The sediments of this stratum were thus observed only in a small pit made with a posthole digger, and knowledge of these sediments is very limited. The floor of the cave apparently was not reached, but rather was stopped by large blocks of roof spall. Unfortunately, there is no way of evaluating how much further down the sediments extend. It should be noted that the water table has been artificially raised in the last 20 years by the damming of the Snake River.

[1]All depths are expressed in relation to an arbitrary vertical datum line (cm bd = centimeters below datum line). The surface of the cave sediments stood at 80 cm bd at the profile point prior to excavation. From 80 cm to 400 cm bd, the profile descriptions are from the west wall (toward cave interior) of Excavation Unit A (0 cm to 200 cm east of horizontal datum line). The descriptions from 400 cm to 630 cm bd are from the west wall of Excavation Unit B (200 cm to 350 cm east of horizontal datum line).

[2]The profile break occurs in Stratum 9. Descriptions from above 400 cm bd are from the west wall of Unit A, and descriptions from below this depth are from the west wall of Unit B.

est and uppermost strata, and it is possible that the process of spalling is under some climatic control (Fryxell et al. 1965).

Following deposition, the sediments of Seed Cave have undergone various processes of change through time. The lower strata show signs of past movements of water and dissolved materials through the deposits. The ash-rich silt and immediately underlying strata have what appear to be compression cracks, suggesting that they may have gone through a period of drying and shrinking following deposition. Finally, several of the uppermost strata, which include abundant organic remains, have been burned in place. The patterning of this burning suggests that the burning occurred in the historic period.

Volcanic Ash Analysis

In the excavation of the Seed Cave deposits, two tephra layers were uncovered. The upper ash (contained in Strata 7 and 9) contains tubular shards that resemble those usually found in tephra from Mount Mazama. If this is indeed Mazama ash, and if it was deposited soon after the eruption, then these strata should date to around 6700 B.P. As discussed in the following section, the radiocarbon dates from immediately below this unit are somewhat younger than the time of the eruption of Mount Mazama, and it seems probable that these deposits represent exhumed and redeposited Mazama tephra. Sediments containing this ash have been found in other parts of eastern Washington to postdate the eruption by thousands of years (Hammatt 1977).

It is of interest to note that no volcanic ashes were observed during the excavations of Windust Cave C (Rice 1965). It seems plausible that the thick lens of ash-rich loess (Stratum 9) in Seed Cave is correlative with the culturally sterile bed of loess (Stratum VIII) in Windust Cave C (Rice 1965:22, 31).

The lower volcanic ash (or possibly ashes) from Seed Cave was found in the form of rounded balls (up to 1 cm in diameter) in Stratum 19. Tubular shards were not observed in these tephra, and it is possible that these ash balls are related to a late Pleistocene or early Holocene eruption of Glacier Peak, Mount St. Helens, or some other Cascade peak. Since the ash has apparently been rolled into rounded balls by water transport, it is possible that this is also an exhumed and redeposited tephra unit. A late Pleistocene volcanic ash from Glacier Peak was found in the lowest sediments at Marmes Rockshelter (Fryxell and Keel 1969).

5. RADIOCARBON ANALYSIS

Robert S. Thompson

All of the radiocarbon dating of materials from Seed Cave was conducted at the University of Arizona. The upper strata in Seed Cave contained numerous plant macrofossils that provided acceptable material for radiocarbon dating. Lower strata, below Stratum 4, have fewer macrofossils, and those that are abundant may cause problems in radiocarbon dating. These lower depositional units include *Celtis* endocarps as the primary organic material. These plant fragments have apparently survived in these sediments principally because they are rich in calcite (Retallack 1983; Yanovsky et al. 1952), and indeed what is recovered from the cave deposits is probably almost pure calcite. If the cave sediments had remained dry since deposition, these endocarps would probably provide a reliable source of material for radiocarbon dating. However, since groundwater has evidently been moving through these strata (see Table 1), there was a chance that these calcareous remains would be contaminated with carbonate of another age.

To circumvent the problems that might result from dating the calcite remnants of hackberry seeds, minute charcoal samples from the lower cave deposits were prepared for analysis with the tandem accelerator/mass spectrometer (TAMS) at the University of Arizona. Laurence J. Toolin, of that laboratory, painstakingly sorted these charcoal pieces from the bulk sediment samples and chemically pretreated them for the TAMS radiocarbon dating. Five dates were obtained from the TAMS analysis of charcoal, one from the conventional CO_2 analysis of charcoal and five from the conventional analysis of *Celtis* endocarps (Table 2).

As can be seen in Table 2 and Figure 9, most of the radiocarbon dates from Seed Cave fall in their correct place in the stratigraphic succession. The TAMS determinations on charcoal overlap with the conventional analyses of *Celtis* endocarps in two areas (Stratum 5 and Strata 9/11). In both cases, there are no indications that the dates on *Celtis* macrofossils are in error. Both TAMS and conventional analyses were performed on materials from 430-440 cm below datum, and these two different methods produced exactly the same ages (6400 B.P.).

Two radiocarbon dates (2780 B.P. at 240-250 cm and 7900 B.P. at 560-570 cm below datum) do appear to deviate from their predicted values based on the temporal trends indicated by the rest of the radiocarbon dates (Figure 9). It is possible, and perhaps probable, that the specimens that produced these apparently erroneous dates were translocated within the cave sediments by the actions of burrowing rodents. Such animals are still active in Seed Cave today.

The radiocarbon dates from Seed Cave suggest that the types and rates of depositional (and perhaps erosional) processes have varied through time. For example, the dates from Stratum 5 seem to indicate that the lower portion of this unit was deposited at a more rapid rate than was the upper portion (Figure 9). A perhaps more important example of this phenomenon is the apparent difference in the rate of deposition of units rich in roof spall in the middle Holocene in comparison to deposits of older and younger ages. As illustrated in Table 3, while the overall rate of deposition (including all sediment types) varied relatively little through time, the rate of roof spalling was apparently only half as rapid between 4100 and 6400 B.P. as the rate that occurred between 100 and 4100 B.P. or between 6400 and 7900 B.P. As mentioned previously, the rate of spalling may be climatically controlled (Fryxell et al. 1965), and thus may indicate that the climate of the middle Holocene was different than those of the early and late Holocene. An alternative explanation for the relative lack of roof spall material in the middle Holocene units would be that more roof spall blocks were deposited and then subsequently removed by erosion. While there is no evidence that this occurred, the possibility cannot be completely discounted.

The sediments of middle Holocene age from Seed Cave contain abundant amounts of volcanic ash that appear to be from Mount Mazama. The radiocarbon dates indicate that the deposition of this tephra post-dated 6400 B.P. and thus probably represents the redeposition of an exhumed bed of Mazama ash. The apparent redeposition of exhumed tephra has been documented in other parts of southeastern Washington (Hammatt 1977).

Table 2. Radiocarbon Determinations from Organic Remains in Seed Cave Deposits.

Depth (cm)	Field Code	Radiocarbon Age	Laboratory Number	Material Dated
140	-	1680 ± 80	A-3710	Charcoal
200-210	Q	3270 ± 300	AA-379	Charcoal
220-230	R	3950 ± 140	A-3711	*Celtis* endocarps
240-250	T	2780 ± 140	A-3712	*Celtis* endocarps
280-290	U	3650 ± 110	A-3713	*Celtis* endocarps
300-310	W	4110 ± 160	A-3714	*Celtis* endocarps
320-330	X	4100 ± 200	A-3715	*Celtis* endocarps
430-440	B	6400 ± 200	AA-375	charcoal
430-440	B	6400 ± 130	A-3716	*Celtis* endocarps
485-495	E	7900 ± 460	AA-376	Charcoal
500-510	F	8370 ± 230	AA-377	Charcoal
560-570	I	7900 ± 310	AA-378	Charcoal

Laboratory numbers beginning with an "A" designate conventional radiocarbon analyses from the University of Arizona with a carbon dioxide counter. Laboratory numbers beginning with a double "A" indicate radiocarbon analyses performed by the Tandem Accelerator/Mass Spectrometer (TAMS) at the University of Arizona.

Table 3. Rates of Deposition of Sediments Over Ca. the Last 7900 Radiocarbon Years in Seed Cave.

Depth (Cm Bd)	Age Range (B.P.)	Duration (14C Yrs)	Total Deposition (in Cm)	Years/CM Total Deposition	Roof Spall Deposition (in Cm)	YRS/CM of Roof Spall Deposition
112-330	100-4100	4000	218	18.35	178	22.47
330-430	4100-6400	2300	100	23.00	35	65.71
430-485	6400-7900	1500	55	27.35	50	30.00

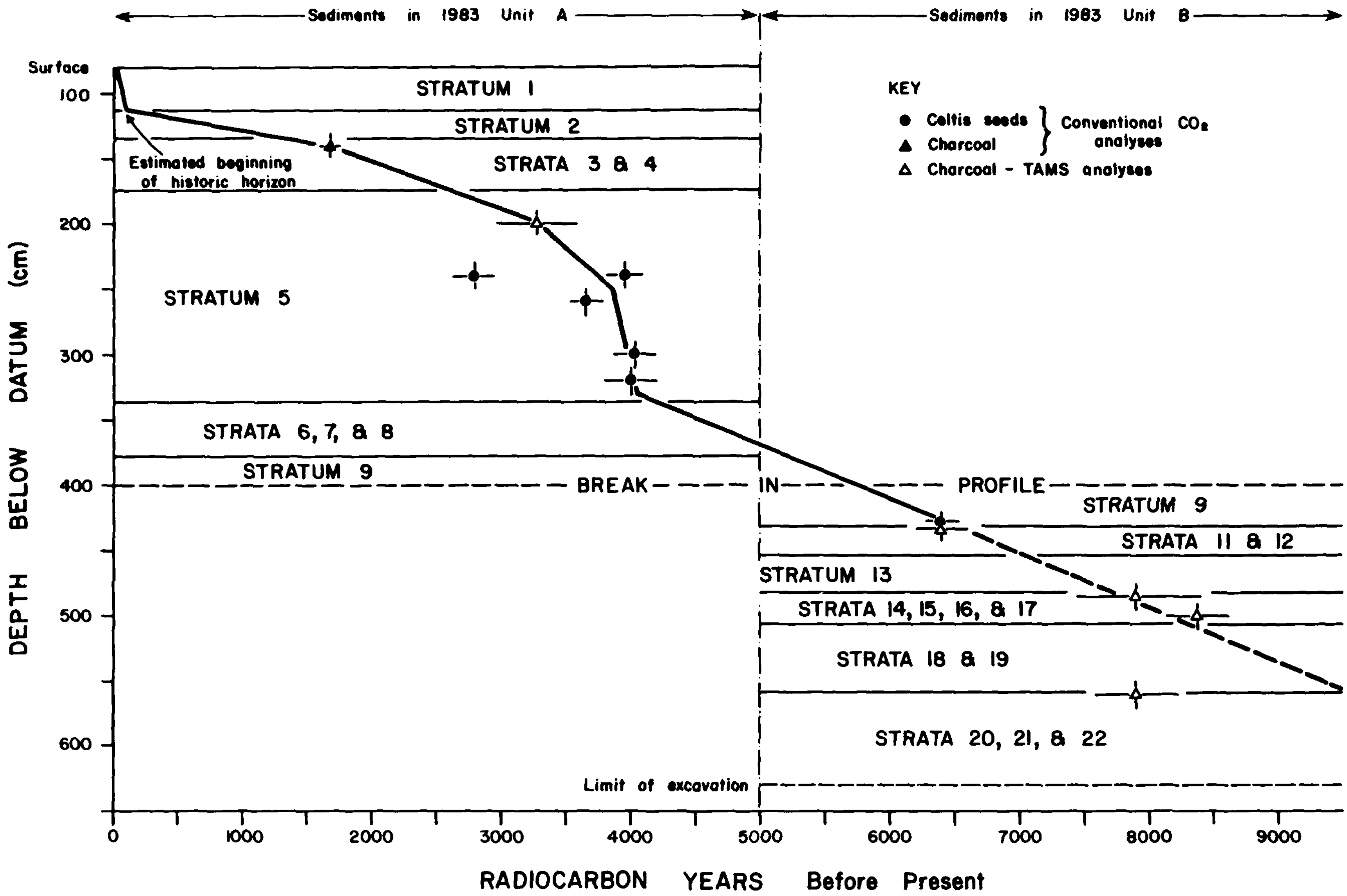

Figure 9. Radiocarbon dates from Seed Cave plotted against the stratigraphy of the site.

6. POLLEN AND PLANT MACROFOSSIL ANALYSIS

Robert S. Thompson

Pollen Analysis

The pollen content was examined from 56 samples from the sediments of Seed Cave. Pollen extraction employed HCl, HF, and KOH to remove unwanted matrix materials. The sample residues were mounted in glycerin, stained, and analyzed under 450X magnification. Microscope slides were counted in non-overlapping traverses evenly spaced across the slide until the sum of terrestrial pollen exceeded 200 pollen grains. The results of the analysis of 27 samples from Seed Cave are shown in Table 4 and illustrated in Figure 10. Unfortunately, little or no pollen was recovered in the samples examined from Stratum 6 and below. This may be due to the action of water moving through these deposits, as we believe the record in the sediments illustrates a fair amount of groundwater activity in the past.

Some of the pollen taxa represented in the Seed Cave diagram are seen in high relative abundances even though these plants do not grow, and probably have not grown, in proximity to the Windust Caves. Pine is an extreme example of this, as modern surface samples from throughout southeastern Washington have relatively high percentages of pine pollen, even if pines do not grow within 80 km (50 mi) of the sample sites (Mack and Bryant 1974). Modern pollen spectra sampled in the Seed Cave area by these authors had pine pollen percentages ranging from 17 to 43. This is an example of the long distance transport of the pollen of a prolific producer being greatly over-represented in a community of low pollen producers. Sagebrush (*Artemisia*) pollen is also over-represented in the plant communities surrounding the Seed Cave area.

The pollen data shown in Figure 10 show two primary patterns. The first is a shift from sagebrush dominance of the non-arboreal pollen (NAP) category below 240 cm below datum to grass dominance from 190 to 140 cm below datum. This shift, which the radiocarbon dates place in the range of 3500 B.P., may reflect a change from more arid conditions in the lower samples to more moist conditions toward the top. The second major change seen in the pollen diagram is the increase in Chenopodiaceae/*Amaranthus* and *Ambrosia*-type pollen in the two uppermost samples of the profile and the two surface samples in comparison with the low representations of these types in the lower sediment samples. The samples with the elevated levels of these taxa are from Stratum 1, which contained many historic mate-

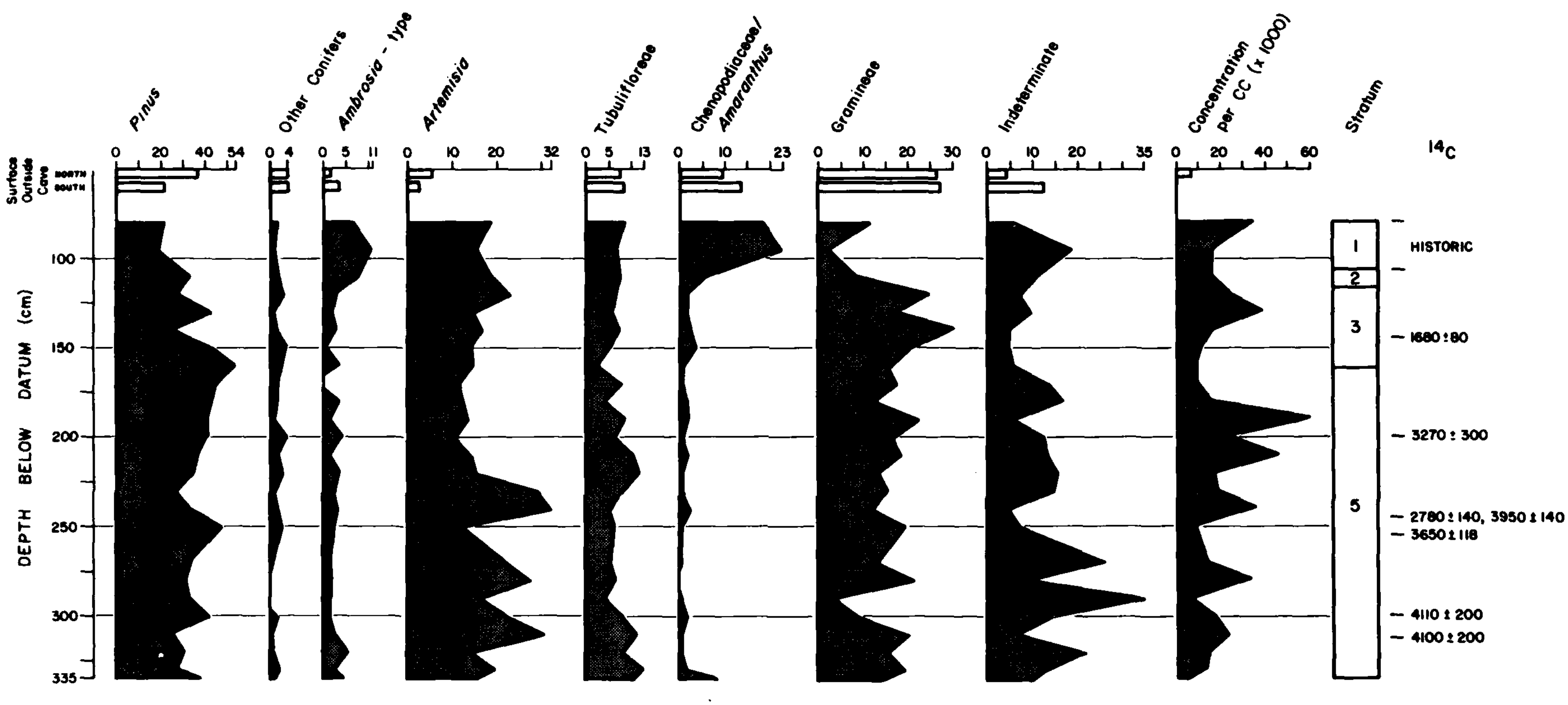

Figure 10. Pollen profile from Seed Cave. The deposits below 334 cm below datum are not illustrated as they did not contain significant amounts of well-preserved pollen (see Table 3). All categories except concentration (pollen per cc) are expressed as percentages of total terrestrial pollen sum.

Table 4. Relative Pollen Percentages from Sediment Samples from Seed Cave.

Depth (Cm)	Abies	Picea	Pinus	Pseudo-tsuga	TCT	Tsuga	Celtis	Quercus	Ambrosia	Artemisia	Tubuli-florae	Chenopo-diaceae
SURFN	0.00	0.00	36.07	0.00	1.37	2.28	0.00	0.91	1.37	5.48	7.76	9.59
SURFS	0.00	0.00	21.85	0.00	3.97	0.00	0.00	0.00	3.64	2.65	8.28	13.91
80	0.31	0.00	21.23	0.00	0.92	0.00	0.00	0.62	6.77	18.46	8.31	18.77
95	0.00	0.00	19.00	0.00	0.33	0.00	0.33	0.00	10.53	15.13	6.91	22.70
110	0.96	0.48	32.54	0.00	0.48	0.00	0.96	0.00	7.18	18.66	7.18	5.74
120	0.00	0.41	26.64	0.00	1.23	0.82	0.00	0.00	2.87	22.54	6.97	1.64
130	0.00	0.49	42.65	0.00	0.00	0.49	0.49	0.00	1.96	14.22	5.88	1.47
140	0.32	0.00	24.52	0.00	0.65	0.32	0.00	0.00	2.90	16.46	7.74	2.26
150	0.94	0.00	43.39	0.00	1.89	0.47	0.00	0.00	0.94	14.15	5.19	3.77
160	0.91	0.45	53.64	0.00	0.00	0.91	0.00	0.00	3.18	14.55	2.72	0.45
170	0.00	0.21	44.30	0.00	0.21	0.84	0.00	0.00	0.00	11.39	7.80	0.42
180	0.33	0.66	42.38	0.00	0.33	0.00	0.00	0.00	3.64	12.91	4.30	1.66
190	0.00	0.00	40.06	0.00	0.00	0.93	0.62	0.31	1.55	13.66	8.70	1.86
200	0.33	1.00	40.67	1.00	0.00	1.33	0.67	0.00	4.00	11.00	6.67	1.00
210	0.77	0.00	36.54	0.00	0.00	1.15	0.00	0.00	1.15	14.23	10.77	1.53
220	0.33	1.00	34.17	0.33	0.00	1.00	1.00	0.00	3.67	15.33	12.00	0.67
230	0.17	0.33	26.58	0.17	0.00	0.33	1.33	0.00	2.82	29.40	7.48	0.33
240	0.58	0.00	32.95	0.00	0.29	0.87	0.00	0.29	3.18	32.37	5.20	2.02
250	0.87	0.00	47.62	0.87	0.43	0.00	0.00	0.00	2.16	12.12	6.06	0.43
270	0.00	0.79	33.07	0.00	0.00	0.00	0.39	0.00	1.58	22.44	5.51	0.79
280	0.00	0.00	30.57	0.00	0.00	0.00	0.00	0.00	1.91	27.39	6.69	0.00
290	0.00	0.00	33.12	0.00	0.00	0.00	0.96	0.00	1.60	16.88	4.14	0.32
300	0.00	0.43	41.28	0.00	0.43	0.43	0.43	0.00	1.28	22.13	8.09	1.28
310	0.00	0.00	25.00	0.00	0.00	0.33	0.33	0.00	2.63	30.60	11.51	0.66
320	0.00	0.00	30.16	0.32	0.00	0.32	0.32	0.00	5.71	14.60	8.57	0.63
330	0.00	0.40	27.60	0.40	0.40	0.80	0.00	0.00	2.80	19.20	13.20	1.20
334	0.47	0.00	39.97	0.00	0.16	0.00	0.95	0.16	4.42	15.64	11.85	7.90

Table 4. (Continued).

Depth (cm)	Grami-neae	Cruci-ferae	Legumi-nosae	Onagra-ceae	Rosaceae	Umbelli-ferae	Other	Indeter-minate	Sum	Concen-tration	<u>Alnus</u>	<u>Salix</u>	Trilete Spores
SURFN	26.94	0.00	0.00	0.00	0.00	0.00	4.10	4.11	219	6500	0.00	0.00	0.46
SURFS	27.15	0.00	0.00	0.00	0.00	0.00	4.63	12.58	302	7000	2.65	0.33	0.00
80	11.08	0.62	0.00	0.00	0.00	0.00	0.92	5.54	325	35100	4.31	0.31	0.62
95	2.63	0.99	0.00	0.00	0.00	0.33	0.65	18.42	304	16400	1.32	0.00	0.66
110	8.61	0.00	0.00	1.44	0.00	0.00	2.46	10.05	209	15800	2.39	0.48	0.48
120	24.59	0.00	0.00	0.00	0.00	1.64	3.69	6.97	244	23100	4.92	0.41	0.00
130	17.16	0.00	0.00	0.00	0.00	0.00	2.97	9.80	204	38600	2.94	0.98	0.00
140	30.00	0.32	0.97	0.00	0.32	0.32	1.94	4.84	310	16400	5.48	0.97	0.00
150	20.75	0.94	0.00	0.00	0.00	0.47	1.42	4.71	212	11200	6.13	0.47	0.00
160	15.91	0.00	0.00	0.00	0.45	0.00	1.82	5.45	220	8500	2.27	0.91	0.45
170	17.72	0.00	0.00	0.00	0.00	0.00	0.21	13.29	474	9600	3.16	0.00	1.27
180	12.91	0.00	0.00	0.00	0.00	0.00	0.99	16.56	302	15200	3.31	0.33	2.64
190	22.36	0.31	0.31	0.00	0.00	0.31	0.93	5.28	322	60900	2.48	0.31	0.00
200	16.67	0.00	0.00	0.00	0.00	1.00	1.15	12.00	300	23500	3.00	0.00	1.33
210	18.46	0.38	0.00	0.00	0.38	0.77	0.66	13.10	260	45400	1.53	1.15	0.38
220	13.33	0.00	0.00	0.00	0.00	0.00	0.99	15.67	300	17900	2.33	0.00	1.67
230	15.61	0.00	0.17	0.00	0.00	0.00	2.00	14.12	602	18700	3.82	0.33	0.50
240	12.43	0.00	0.00	0.00	0.58	0.00	1.45	4.62	346	35700	3.47	0.00	0.00
250	19.91	0.00	0.00	0.43	0.00	0.00	2.16	6.92	231	9500	3.90	0.00	0.00
270	13.78	0.39	0.00	0.00	0.00	0.00	1.58	25.98	254	13700	1.57	0.00	0.00
280	21.34	0.00	0.00	0.00	0.32	0.00	0.64	9.55	314	32400	1.59	0.00	0.32
290	3.50	0.00	0.00	0.32	0.00	0.00	1.28	35.35	314	6600	2.58	0.32	0.00
300	9.79	0.00	0.00	0.00	0.00	0.00	0.00	14.47	235	16700	2.13	0.00	0.00
310	20.34	0.00	0.00	0.00	0.00	0.00	0.33	6.91	304	22300	1.32	0.00	0.00
320	15.87	0.00	0.00	0.63	0.00	0.00	0.95	21.90	315	14000	3.17	0.00	0.63
330	19.60	0.00	0.00	0.00	0.00	0.40	0.80	12.80	250	12600	2.80	0.00	0.00
334	14.38	0.00	0.00	0.47	0.00	0.00	1.74	9.48	633	5300	1.58	0.00	0.00

rials, and this phenomenon probably reflects the introduction of new steppe chenopods from Eurasia and the habitat disturbances in the vegetation of the region caused by agriculture and overgrazing. Similar effects are seen in the record from Wildcat Lake (Davis et al. 1977).

When the Seed Cave pollen data were examined, it was determined that the shifts in NAP might be due to statistical factors (constraint inherent in percentage data) or to depositional factors that might be reflected in pollen concentration. To test these ideas, a correlation matrix was constructed with six major pollen taxa and total pollen concentration (Table 5). In Matrix A, which includes the surface and historic samples, Chenopodiaceae/Amaranthus and Ambrosia-type pollen are significantly and positively correlated, and both of these types are significantly and negatively correlated with Pinus pollen. This latter inverse relationship suggests that the long-distance pine pollen signal is being "drowned" during the historic period by the pollen of local disturbance plants. The negative significant correlation between Ambrosia-type and Gramineae pollen in this matrix could reflect the replacement of the pollen of the natural grassland of the region with the pollen of disturbance plants during the historic period. In any case, the correlations in Matrix A suggest that statistical constraint is a factor in the pollen diagram.

Matrix B (Table 5) presents the correlation coefficients between the same array of taxa as in Matrix A, but with the historic and surface samples removed from the analysis. Chenopodiaceae/Amaranthus and Ambrosia-type still have a significant positive correlation in this matrix, indicating that these indicators of disturbance and/or aridity co-vary through the prehistoric portion of the pollen diagram. These two taxa are not significantly and negatively correlated with any other taxa in Matrix B, suggesting that they are not exerting a great degree of statistical constraint, as they do in Matrix A. There are, however, significant negative correlations between Pinus and Artemisia and between Pinus and Tubulifloreae. As mentioned above, the Pinus pollen is almost undoubtedly from very long distance transport, while the Artemisia and Tubulifloreae pollen probably were derived from more local sources (though not necessarily from plants growing near the cave mouth). The negative relationship between pine pollen and these other taxa may thus represent variations in the representations of "extra-local" vs. long-distance sources of pollen.

As discussed above, it appears that Artemisia pollen is more abundant in the lower portion of the pollen profile (below 220 cm) than in the upper portion. To test this relationship, and to see if there were any other significant differences between these two parts of the profile, a Student's T-test of the differences between the means of the two periods for each taxon was conducted (Sokal and Rohlf 1969). This test indicates that there is a significant difference in the level of Artemisia pollen between the upper and lower portions of the diagram (Table 6). None of the other pollen types exhibit any significant differences between the two periods.

The absolute concentrations of pollen (pollen/cc) are shown on the far left on the pollen diagram (Figure 10). There are no demonstrably significant variations in concentrations through the profile. This seems a little unusual since the radiocarbon dates suggest that the lower portion of Stratum 5 was deposited much more rapidly than the rest of the sediments covered by the pollen profile. If pollen influx rates were relatively constant, a more rapid rate of deposition could be expected to lead to lower pollen concentration as the pollen would be "diluted" by a larger volume of sediment.

Plant Macrofissil Analysis

The plant remains from the bulk samples from Seed Cave were examined and all specimens were referable to the genus Celtis. A few nutlets from a species in the Boraginaceae were also recovered. The historic strata (1 and 10) do contain pieces of driftwood, ponderosa pine bark, juniper bark, and a few other remains. These organic materials are certainly the result of activities of Euroamericans over the last century.

Table 5. Correlation matrices from relative pollen frequencies from Seed Cave. Upper matrix (A) includes all samples; lower matrix (B) excludes surface samples and samples of historic age. The null hypothesis is that the given correlation coefficient is not significantly different from a value of zero at the .05 level (that is, no correlation exists). In Matrix A there are 25 degrees of freedom, and the correlation coefficient must exceed an absolute value of 0.381 to indicate a significant correlation (Sokal and Rohlf 1969). In Matrix B there are 21 degrees of freedom, and the correlation coefficient must exceed an absolute value of 0.396 to indicate a significant correlation. Statistically significant correlation values are underlined in both matrices.

	Pinus	*Ambrosia*	*Artemisia*	Tubulifloreae	Chenopodiaceae/ *Amaranthus*	Gramineae	Concentration
MATRIX A							
Pinus	1.000						
Ambrosia	<u>-0.489</u>	1.000					
Artemisia	-0.284	-0.012	1.000				
Tubulifloreae	-0.361	0.058	0.036	1.000			
Chenopodiaceae/ *Amaranthus*	<u>-0.502</u>	<u>0.690</u>	-0.303	0.077	1.000		
Gramineae	-0.008	<u>-0.475</u>	-0.233	0.199	-0.205	1.000	
Concentration	-0.061	-0.074	0.262	0.110	-0.073	0.077	1.000

9. SUMMARY AND MANAGEMENT RECOMMENDATIONS

Robert S. Thompson

Although the Seed Cave sediments did not contain a significant archaeological record, a great deal of paleoenvironmental information was recovered from this site. The changes in the local environment are reflected in stratigraphic, palynological, and faunal data. These environmental fluctuations are summarized below in chronological order.

Ca. 9000 to 6400 Years B.P.

The data that are available from this period primarily are from stratigraphic and faunal studies. The depositional regime of this period includes a considerable amount of roof spalling, perhaps reflecting relatively cool and moist conditions. The faunal data do not indicate that the local environment differed greatly from that of today. Two lenses of unidentified tephra were found in the deposits from this interval.

6400 to 4100 Years B.P.

Relatively little roof spall material was deposited during this period, and the sediments are dominated by loess that is rich in what appears to be redeposited Mazama ash. The sediments below this loess have what are apparently dessication cracks, which, together with the relative lack of roof spall, may indicate very dry conditions. No faunal or pollen data were recovered from this interval.

4100 to Ca. 3500 Years B.P.

Sediments with abundant roof spall material are dominant during this interval, perhaps indicating less arid conditions than during the preceding period. The faunal data provide a weak indication of relatively moist conditions, while the pollen spectra suggest that it was still more arid than during the modern period.

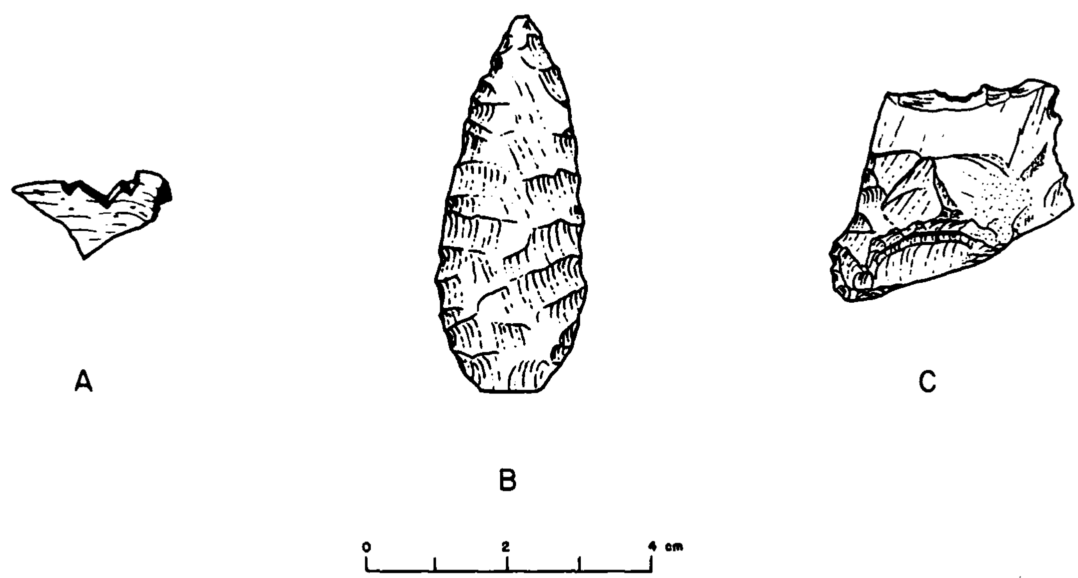

Figure 11. Archaeological materials recovered from Seed Cave.

not change the local environment all that much. In a similar vein, perhaps riverine archaeological sites are not necessarily the best places to look for cultural changes, as the activities reflected in these sites would be minimally affected by environmental fluctuations.

Table 8. Prehistoric Artifacts from Seed Cave.

Depth (cm)	Artifact	Description
430-450	Flake	Tertiary thinning flake; basalt.
430-450	Worked bone fragment (Figure 11a)	Three notches have been cut in the proximal (?) end of this unidentified bone fragment.
470-490	Projectile point/ knife (Figure 11b)	Lanceolate point, bifacially worked, acute tip, biconvex cross section, broad collateral pressure flaking, heavily carbonate-encrusted; basalt, 51 x 21 x 5 mm; 7 g.
500-520	Flake scraper/ graver (Figure 11c)	The margins of this cryptocrystalline flake are unifacially worked and/or utilized in three places; 42 x 30 x 9 mm.

8. ARCHAEOLOGICAL MATERIALS RECOVERED AT SEED CAVE

Glenn D. Hartmann

The first archaeological investigations at the Windust Caves in 1959 were test excavations by Harvey S. Rice, which subsequently resulted in extensive excavations of Cave C in 1960-1961 (Rice 1965). Three of the Windust Caves were tested, the first being Cave H (Seed Cave). As mentioned previously, the results of this effort were so meager that excavations were abandoned at a maximum depth of 10 ft. Testing in Cave F produced no prehistoric cultural materials at all. It was the results of the initial excavations in Cave C, however, that warranted an additional two seasons of fieldwork.

Cultural materials recovered from Cave C allowed Rice (1965) to construct a cultural sequence for almost 10,000 years of prehistory. Significant in these excavations was the stratigraphic placement of point styles which allowed for the relative dating of assemblages from elsewhere in the Plateau.

The present investigations at Seed Cave focused on the paleoenvironmental aspects of the cave deposits. Although previous investigations (Rice 1965; Cleveland et al. 1976; Gross 1979) had not recovered any archaeological materials to suggest that there might be extensive cultural deposits, the continued activity of relic collectors within the cave suggested that there was the possibility of finding some archaeological materials. The excavation strategy and field techniques employed in the present effort were designed, in part, to accommodate the recovery of archaeological materials, had such materials been present. As indicated below in Table 8, only four prehistoric artifacts were found, three of which are illustrated in Figure 11. The relative lack of archaeology is consistent with Rice's testing results (1965) and reinforces his interpretation of the unsuitability of Seed Cave for human habitation.

The effect of environmental changes on the prehistoric inhabitants of the Plateau has long been of interest to archaeologists (cf. Bense 1972). Recent paleoenvironmental investigations near Seed Cave (Kolva 1975; Davis et al. 1977; Bartholomew 1982) have demonstrated climatic variability during the Holocene, although archaeologists have not always been able to discern concomitant variation in the archaeological record (cf. Schalk 1983). While changes through time in the Seed Cave record appear to be minimal, this is not entirely unexpected given the riparian environment in which the cave is located. Slight changes in mean temperature and/or precipitation would likely

Most of the mammalian taxa occur too sporadically in the Seed Cave record to allow detection of trends through time. The rodents are the only exception to this statement. Within this group, Perognathus (pocket mouse) is most abundant below Stratum 16 (485-495 cm below datum), while Microtus (vole) and Spermophilus (ground squirrel) are more abundant above Stratum 6 (above 320 cm). Pocket mice usually prefer open sandy habitats (desert scrub or grassland), while voles generally require more closed vegetation and a higher level of effective moisture. This latter habitat could merely be a narrow moist corridor of vegetation along the river. Ground squirrels, depending upon the species, can inhabit environments from desert to boreal forests, and thus do not provide an identifiable paleoenvironmental signal.

No faunal remains were present in sample A from Stratum 9 (400-410 cm below datum) at the top of the thick lens of volcanic ash-rich silt. Sample AA (370-380 cm) and samples G and H (520 to 550 cm) had very depauperate faunal assemblages. We do not know whether these samples represent environmental changes, periods of rapid deposition, or other causes. The samples from non-sandy deposits below Stratum 16 (Sample E, 485-495 cm) have the highest concentrations of bones in the profile. The sediments that these samples were taken from appear to be lag deposits and may be enriched by depositional or erosional processes.

Discussion of the Faunal Data

The faunal record from Seed Cave suggests that this site has been a raptor roost throughout the last 8000 or so radiocarbon years. No extinct or extralocal fauna were observed in the collection, and the changes in faunal representations through time seem to reflect only very minor environmental fluctuations. The sparsity of animal remains in the samples from near the top of the volcanic ash-rich silt layer (Samples A and AA) might be a reflection of the environmental conditions that led to an apparent absence of deposition of other sediments during the middle Holocene. The fauna in the samples from above this layer do not seem to indicate any major differences between modern and past environments near Seed Cave. However, these faunal remains do seem to indicate that the vegetation of the "post-ash" deposits was more dense and less open than that of the "pre-ash" vegetation.

19 (520-550 cm). No raptor remains were recovered from any of the samples from Seed Cave.

Mammals

Mammals are by far the most common class represented in the Seed Cave fauna, and this group is the second largest in terms of identifiable remains. Though diversity is low in the Mammalia, it is greater than in any other class recovered from the Seed Cave deposits. As more of the Rodentia (rodents) are segregated in the final analyses, the apparent diversity of mammals in the Seed Cave record will undoubtedly increase.

Two bats were recovered: cf. *Antrozous pallidus* (pallid bat) and *Myotis* sp. (evening bat). Both genera occur today in the region. Within the order Lagomorpha (lagomorphs), both *Lepus* (jackrabbit) and *Sylvilagus* (*S. nuttalli*--mountain cottontail--and *Sylvilagus* sp.) were identified. These leporids are common elements in the modern local fauna.

Rodents were the most common mammals represented in the Seed Cave collection. Remains of animals in the family Sciuridae (squirrels) were the most abundant of the rodent remains. Only one genus, *Spermophilus* (ground squirrel), has been segregated, and two or more species in this genus may be represented in the samples. The next most abundant rodent taxon was *Perognathus* sp. (pocket mouse) in the family Heteromyidae. Like the squirrels, more than one species may be represented in this genus. *Microtus* sp. (meadow voles, family Cricetidae) is the fourth most common rodent. The apparent number of this taxon may be reduced when all specimens are double-checked against specimens of *Lagurus curtatus* (sagebrush vole), a very closely related animal that is also represented in the Seed Cave fauna. Another cricetid group, *Peromyscus*/*Reithrodontomys*, is probably also represented by two or more species. *Neotoma cinera* (bushy-tailed packrat), also in the Cricetidae, is present at low levels in the record. *Thomomys* sp. (pocket gopher, family Geomyidae) is as abundant in the record as the *Peromyscus*/*Reithrodontomys* group, and may be represented by only a single species.

Only two carnivores (order Carnivora) were identified from the Seed Cave collection--*Mustela ermina* (ermine, family Mustelidae) and *Urocyon cinereoargenteus* (gray fox, family Canidae). Ermine live on the Columbia Plateau today, though we are not certain that they can be found near Seed Cave. Gray foxes probably do live in the proximity of the cave today. Though remains of animals in the order Artiodactyla (even-toed ungulates) are not abundant in the cave deposits, these remains are present throughout the record. The fragmentary nature of these remains has prohibited their identification below the order level.

Reptiles (Snakes)

Most of the 5933 snake bones from Seed Cave are vertebrae, though a number of dentaries, maxillae, and other skull fragments were also recovered. None of the snake remains have been identified below the family level at this time. Both the Colubridae (the common constricting snakes) and the Viperidae (Crotalidae, the rattlesnakes) families are present in the record and the region today. Snake remains are very common throughout most of the cave deposit, except for Stratum 9 (400 to 410 cm below datum) and the lower portion of Stratum 19 (540 to 550 cm below datum).

Reptiles (Lizards)

There are 76 bones of lizards that have been segregated from the Seed Cave sediment samples. Only 48 of these specimens could be identified to the generic level, and all of these are in the family Iguanidae (iguanids). *Phyrnosoma douglassi* (short-horned lizard) is the dominant taxon. *Sceloporus graciaosus* (sagebrush lizard) and *S. occidentalis* (western fence lizard) were also identified (one dentary of the former species and two of the latter). All three of these species live today in the area around Seed Cave.

Birds

A minimum of 257 bird specimens has been sorted from the sediment samples. The work thus far indicates that the remains of the passerines, family Passeriformes (perching birds) are very abundant. Generic and specific identifications of the remains of birds of this order are very difficult due to the great diversity and taxonomic affinities of these animals. Steadman has found that within this group there are representatives of the families Fringillidae (finches and sparrows) and Alaudidae (larks). Magpie (*Pica pica*) and finch (*Carpodacus*) remains have been identified from the sample from 350-360 cm below datum, and the bones of a mourning dove (*Zenaidura macroura*) were recovered from the sample from 300-310 cm.

Also abundant within the Seed Cave samples are the bones of birds resembling sagegrouse in the Tetraonidae (grouse family) within the order Galliformes (gallinaceous birds). A few remains of waterfowl (order Anseriformes, family Anatidae) are also present in the Seed Cave sediments. Bird remains are present throughout the stratigraphic profile except in Strata 5 (280-290 cm below datum), 9 (400-450 cm), 10 (450-460 cm), and

Table 7. (Continued).

CLASS:	MAMMALIA			
Order:	Carnivora		Artiodactyla	
Family:	Mustlidae	Canidae	Indeterminate	
Genus:	Mustela	Urocyon		
species:	erminea	cinereoargenteus		TOTAL
SAMPLE/DEPTH:				
J/90-110	-	-	-	0
K/120-130	-	-	-	33
L/140-150	-	-	-	33
M/160-170	-	-	-	29
N/160-170	-	-	-	0
O/180-190	-	-	-	0
P/180-190	-	-	-	33
Q/200-210	-	-	-	18
R/220-230	-	-	-	45
S/240-250	1	-	1	204
T/240-250	-	-	-	67
U/260-270	-	-	1	103
V/280-290	-	-	-	0
W/300-310	-	-	-	386
X/320-330	-	-	1	255
Y/340-350	-	-	-	0
Z/350-360	-	-	-	293
AA/370-380	-	-	-	27
A/400-410	-	-	-	1
B/430-440	-	-	-	883
C/450-460	-	-	-	0
D/467-477	-	-	-	947
E/485-495	-	-	-	541
F/500-510	-	-	-	1532
G/520-530	-	-	-	23
H/540-550	-	-	-	0
I/560-570	-	-	-	1166
B'/580-600	-	-	-	1232
SUM	1	1	5	7802

Table 7. (Continued).

CLASS:	MAMMALIA							
Order:	Rodentia							
Family:	Heteromyidae	Geomyidae	Sciuridae	Cricetidae				
Genus:	<u>Perognathus</u>	<u>Thomomys</u>	<u>Spermophilus</u>	<u>Peromyscus/</u>	<u>Neotoma</u>	<u>Neotoma</u>	cf. <u>Lagurus</u>	<u>Microtus</u>
Species:	sp.	sp.	sp.	<u>Reithrodontomys</u>	<u>cinerea</u>	sp.	<u>curtatus</u>	sp.
SAMPLE/DEPTH:								
J/90-110	-	-	-	-	-	-	-	-
K/120-130	3	2	1	-	-	-	13	-
L/140-150	1	2	3	-	-	-	24	-
M/160-170	1	-	8	1	-	-	3	4
N/160-170	-	-	-	-	-	-	-	-
O/180-190	-	-	-	-	-	-	-	-
P/180-190	-	5	8	-	-	-	-	9
Q/200-210	-	-	1	-	-	-	-	5
R/220-230	-	2	11	1	-	-	1	4
S/240-250	-	6	30	3	-	-	1	23
T/240-250	-	2	11	-	3	-	-	8
U/260-270	1	3	20	4	-	-	-	11
V/280-290	-	-	-	-	-	-	-	-
W/300-310	12	16	40	3	-	3	-	87
X/320-330	1	4	20	-	-	1	-	24
Y/340-350	-	-	-	-	-	-	-	-
Z/350-360	6	7	21	5	-	-	-	1
AA/370-380	16	-	-	4	-	-	-	-
A/400-410	-	-	-	-	-	-	-	-
B/430-440	5	7	5	3	-	-	-	5
C/450-460	-	-	-	-	-	-	-	-
D/467-477	12	10	10	10	-	-	-	-
E/485-495	1	25	17	4	-	-	-	5
F/500-510	77	45	32	32	-	1	-	8
G/520-530	9	3	-	-	-	-	-	-
H/540-550	-	-	-	-	-	-	-	-
I/560-570	63	23	11	34	-	1	-	2
B'/580-600	26	39	23	6	-	-	-	4
SUM	234	123	272	110	3	6	42	213

Table 7. (Continued).

CLASS:	AVES	MAMMALIA					
Order:	Unidentified	Chiroptera			Lagomorpha		
Family:		Vespertillionidae			Leporidae		
Genus:		cf. *Antrozous*	*Myotis*	cf. *Pioestrellus*	*Lepus* sp.	*Sylvilagus*	*Sylvilagus*
Species:		*pallidus*	sp.	sp.		*nuttalli*	sp.
SAMPLE/DEPTH:							
J/90-110	-	-	-	-	-	-	-
K/120-130	1	-	-	-	-	-	-
L/140-150	-	-	-	-	-	-	-
M/160-170	-	-	-	-	-	-	-
N/160-170	-	-	-	-	-	-	-
O/180-190	-	-	-	-	-	-	-
P/180-190	-	-	-	-	-	-	-
Q/200-210	1	-	-	-	-	-	-
R/220-230	1	-	-	-	-	-	-
S/240-250	5	-	-	1	-	-	3
T/240-250	6	-	-	-	-	-	-
U/260-270	8	-	-	-	1	-	-
V/280-290	-	-	-	-	-	-	-
W/300-310	27	-	1	-	1	-	2
X/320-330	17	2	-	-	-	-	3
Y/340-350	-	-	-	-	-	-	-
Z/350-360	15	-	-	2	2	7	-
AA/370-380	1	-	-	-	-	-	-
A/400-410	-	-	-	-	-	-	-
B/430-440	18	-	-	-	-	-	-
C/450-460	-	-	-	-	-	-	-
D/467-477	32	-	-	-	-	-	-
E/485-495	19	-	-	-	-	-	-
F/500-510	45	-	-	-	-	-	-
G/520-530	-	-	-	-	-	-	-
H/540-550	-	-	-	-	-	-	-
I/560-570	39	-	3	-	-	-	-
B'/580-600	22	-	-	2	-	-	-
SUM	257	2	4	5	5	7	8

Table 7. Faunal Remains from the Seed Cave Deposits.

	PISCES	AMPHIBIA		REPTILIA				
CLASS:	PISCES	AMPHIBIA		REPTILIA				
Order:	Unidentified	Anura		Squamata	Squamata			
Family:		Pelobatidae	Bufonidae	(Serpentes)	Iguanidae			
Genus:		Scaphicpus	Bufo sp.		Phrynosoma	Phrynosoma	Sceloporus	Sceloporus
Species:		sp.			douglassi	sp.	graciosus	cf. occidentalis
SAMPLE/DEPTH:								
J/90-110	-	-	-	-	-	-	-	-
K/120-130	6	-	-	7	-	-	-	-
L/140-150	-	-	-	3	-	-	-	-
M/160-170	-	-	-	12	-	-	-	-
N/160-170	-	-	-	-	-	-	-	-
O/180-190	-	-	-	-	-	-	-	-
P/180-190	6	-	-	5	-	-	-	-
Q/200-210	6	-	-	4	1	-	-	-
R/220-230	7	-	-	17	-	-	-	-
S/240-250	17	-	-	113	-	-	-	-
T/240-250	9	-	-	28	-	-	-	-
U/260-270	12	-	-	42	-	-	-	-
V/280-290	-	-	-	-	-	-	-	-
W/300-310	45	2	-	145	2	-	-	-
X/320-330	10	-	-	171	-	-	-	1
Y/340-350	-	-	-	-	-	-	-	-
Z/350-360	62	-	-	148	3	-	1	-
AA/370-380	2	-	1	3	-	-	-	-
A/400-410	-	-	-	1	-	-	-	-
B/430-440	50	-	-	787	3	-	-	-
C/450-460	-	-	-	-	-	-	-	-
D/467-477	53	1	-	818	1	-	-	-
E/485-495	39	-	-	427	4	-	-	-
F/500-510	105	-	-	1176	9	2	-	-
G/520-530	-	-	-	11	-	-	-	-
H/540-550	-	-	-	-	-	-	-	-
I/560-570	39	-	-	937	12	-	-	2
B'/580-600	21	-	2	1078	-	8	-	-
SUM	489	3	3	5933	35	10	1	3

7. FAUNAL STUDIES

Jim I. Mead, Emilee Mead, and D.W. Steadman

The sediment samples from Seed Cave are very rich in faunal remains (Table 7). There are at least 7786 identifiable bones from these samples, with approximately 10,000 additional specimens that are unidentifiable beyond the class Mammalia. Within the identifiable remains, most belong to snakes (5933 specimens), and mammals are the next most abundant group (1187). These numbers do not necessarily accurately reflect the relative number of individuals of these two taxa, since nearly all skeletal remains of snakes are identifiable below the suborder Serpentes, while in the mammalian category, only those remains that were referable to at least the generic level were "identified." Most of the sediment samples collected for faunal remains contained bones. None of the taxonomic groups are represented in any great diversity in the Seed Cave deposits.

Fish

There are 483 fish specimens recovered from the Seed Cave samples, and these have not been identified below the class level. Fish bones were recovered from throughout the sedimentary sequence except for Stratum 9 (400 to 410 cm below datum).

Amphibians

Only six bones of amphibians were recovered from the entire deposit, and only two genera were identified: *Bufo* and *Scaphiopus*. The faunal remains of these taxa were fragmentary and thus the species could not be unequivocally identified. Within the genus *Scaphiopus*, only *S. intermontanus* (Great Basin spadefoot toad) lives in the Columbia Plateau region today, and this is probably the species represented in the Seed Cave sediments.

Two species of *Bufo* live near Seed Cave today: *B. boreas* (western toad) and *B. woodhousei* (Rocky Mountain toad). The latter species may be in a "relictual" situation along the Washington-Oregon border (Stebbins 1966). Although the species could not be determined, the vertebra and two humeri that were recovered were from two separate individuals with snout-vent lengths in excess of 115 and 130 mm.

Table 6. Results of Student's T-test for comparing the means of the pollen representations for various taxa between two sets of samples (110-220 cm vs. 230-334 cm). At the .05 level (df=21), the value of T must exceed an absolute value of 2.080 to indicate a statistically significant difference between the means of the two sets of samples. The sole statistically significant T value is underlined.

Taxon	Student's T Value
Pinus	1.590
Ambrosia-type	0.026
Artemisia	-3.197
Tubulifloreae	-0.747
Chenopodiaceae/*Amaranthus*	0.583
Gramineae	1.331
Concentration	1.206

Table 5. (Continued).

	Pinus	Ambrosia	Artemisia	Tubulifloreae	Chenopodiaceae/Amaranthus	Gramineae	Concentration
MATRIX B							
Pinus	1.000						
Ambrosia	-0.229	1.000					
Artemisia	-0.615	0.011	1.000				
Tubulifloreae	-0.422	0.112	0.070	1.000			
Chenopodiaceae/Amaranthus	0.055	0.435	-0.127	0.207	1.000		
Gramineae	-0.196	-0.230	-0.041	0.214	-0.088	1.000	
Concentration	-0.087	-0.204	0.132	0.116	-0.125	0.287	1.000

Ca. 3500 to the Present

None of the paleoenvironmental indicators provide any evidence that the environment around Seed Cave varied substantially over this interval. The pollen data do indicate that the effects of historic activities have been great, and that the modern vegetation is dominated by disturbance plants and introduced plants from Eurasia that were not present over most of the last 3500 years.

Recommendations

Following the present excavations, the site was backfilled with sterile sand to stabilize the profile. Thus there is additional information remaining in Seed Cave which is available if the reservoir would be drawn down to allow excavation of the present supersaturated sediments. The site should be monitored by Corps personnel, and if vandalism becomes a problem in the future, it may be necessary to develop additional preservation measures.

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